ATLAS at MPP during 2010

MPP Project Review, 20th December 2010

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on behalf of the ATLAS MPP group

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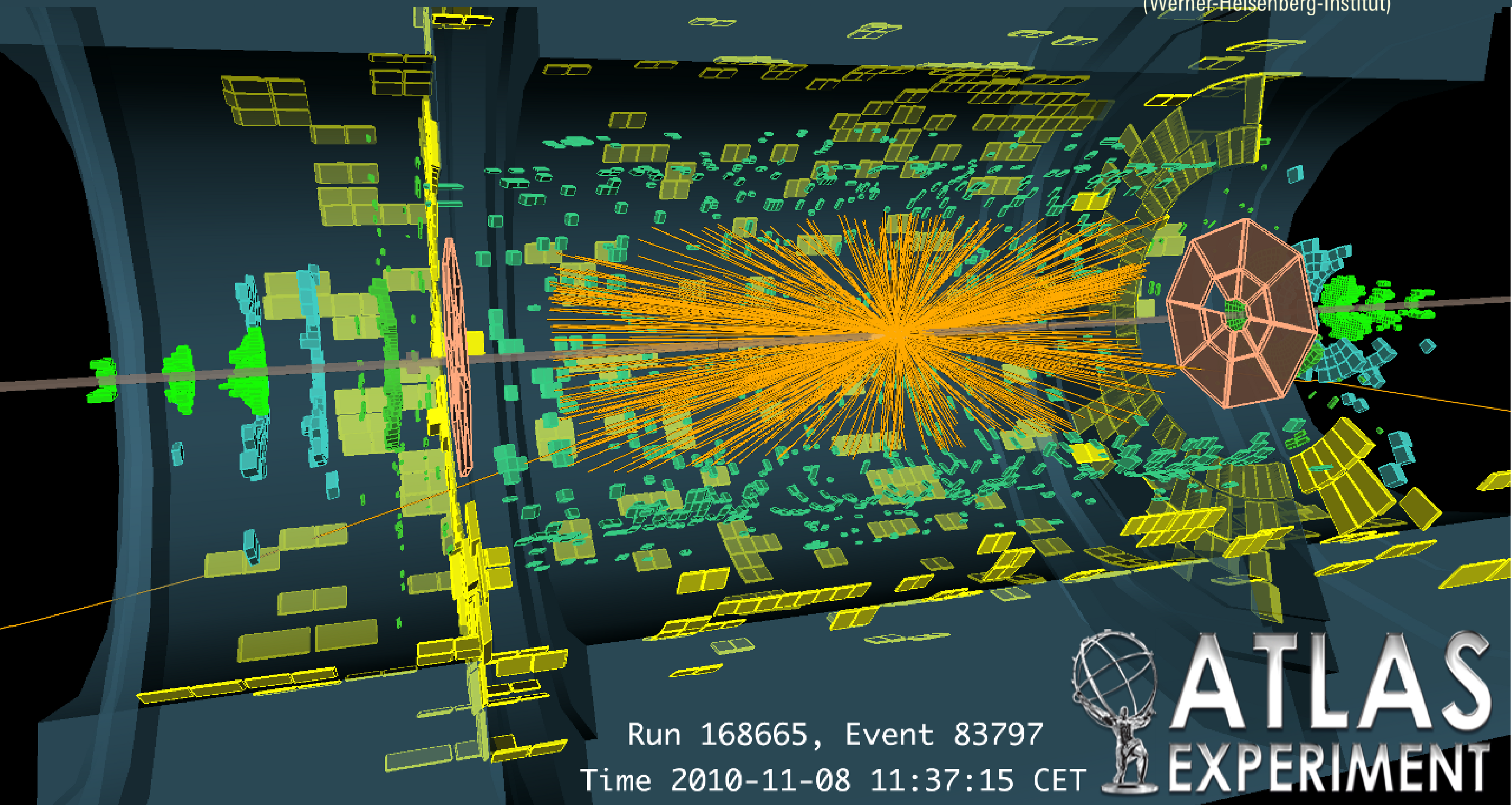

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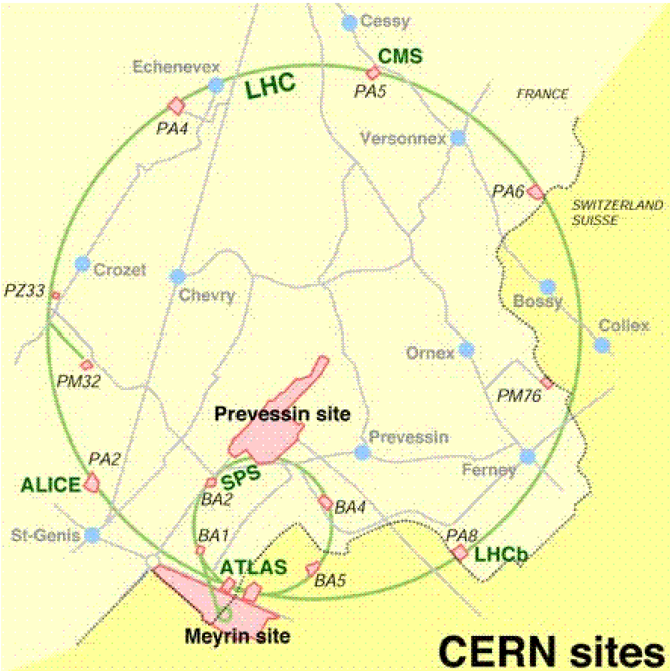
Outline

- Introduction
- The Machine and the Detector in 2010
- MPP in ATLAS
  - Alignment and calibration
  - LHC data analysis
  - R&D projects for LHC upgrade
- LHC and ATLAS plans for 2011
- Conclusion

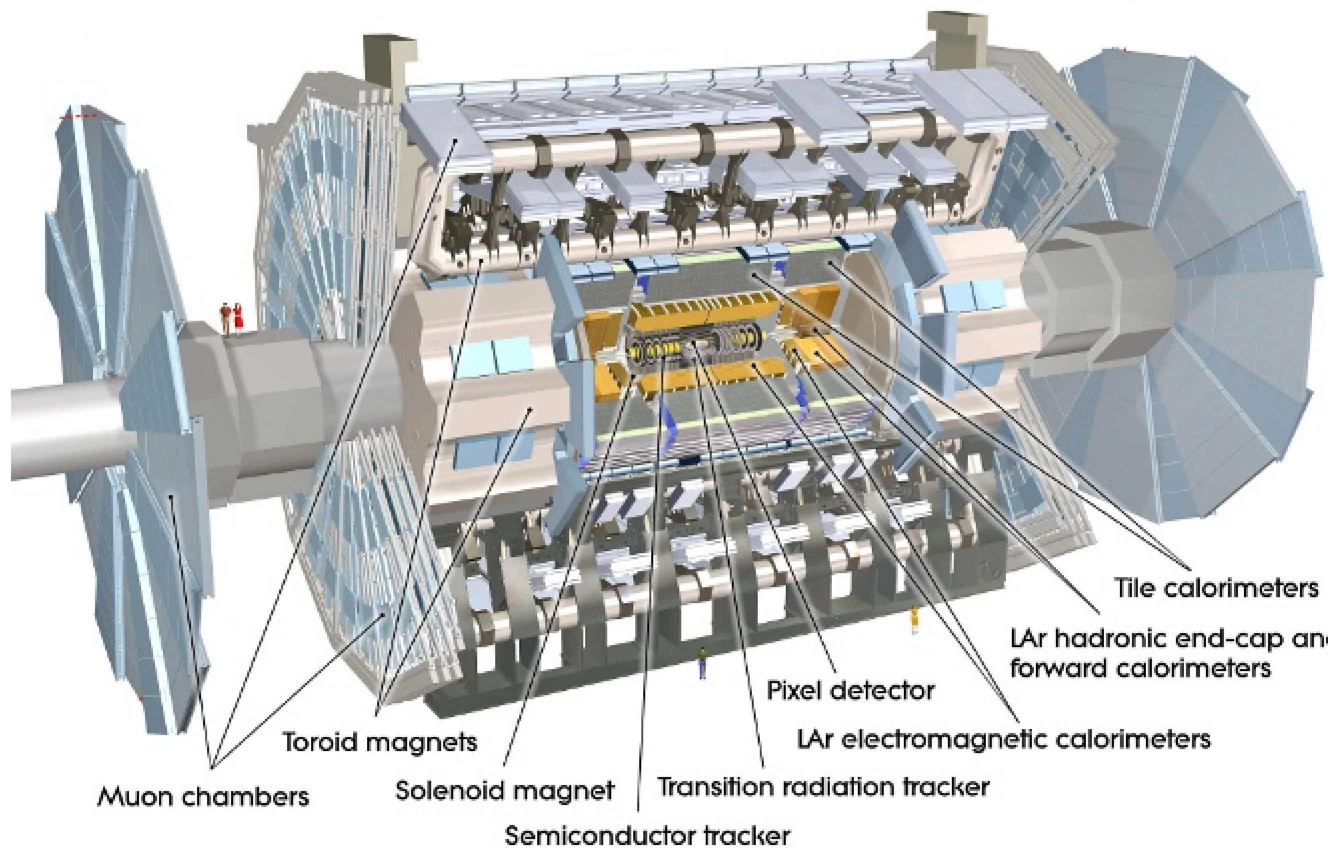
ATLAS detector - **A** **T**oroidal **LHC** **A**pparatu**S**



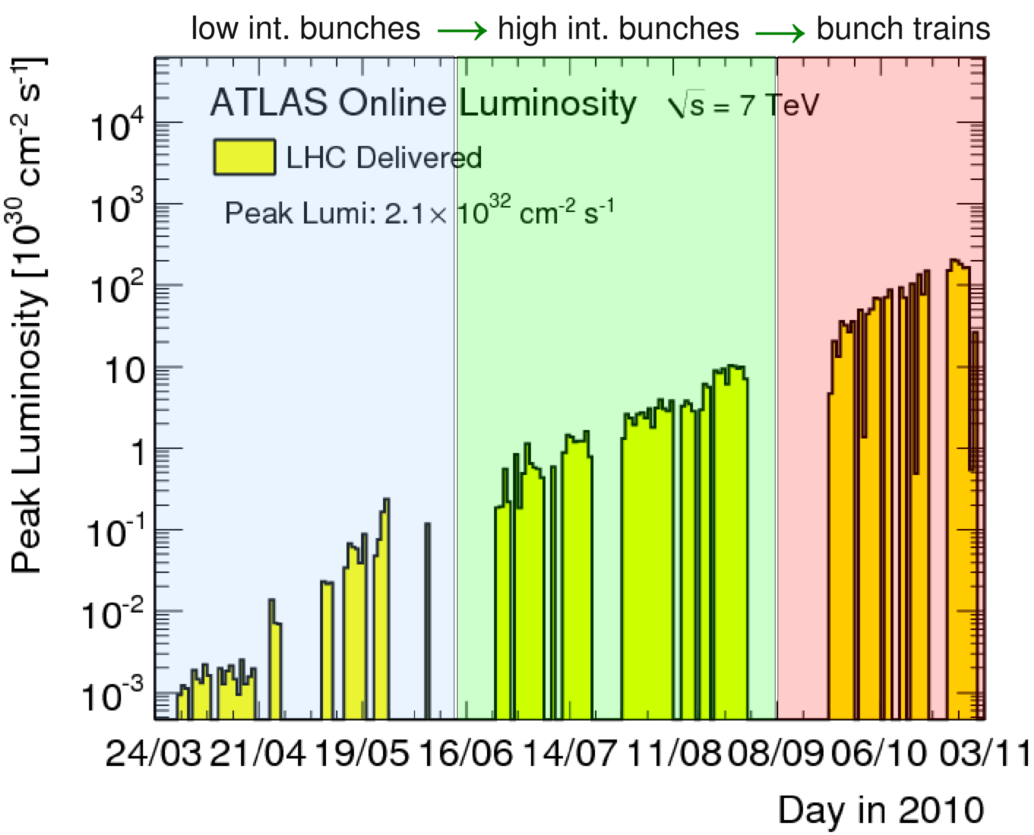
General purpose detector installed on Large Hadron Collider at CERN, Geneva, Switzerland

25 m high, 44 m long, 7000 t heavy, 100 m under the surface
3000 scientists from 38 countries
20 years of design, development and fabrication

- August 2008
  ATLAS completed
- September 10, 2008
  First beam at LHC
- September 19, 2008
  Start of 14 month repair campaign
- November 20, 2009
  Beam in the LHC again
- December 15, 2009
  20 μb^{-1} $\sqrt{s}$ = 900 GeV, L_{inst}=4.6x10^{26} cm^{-2} s^{-1}



LHC in 2010 - proton-proton 7 TeV period



Beginning of the year
450 GeV p-p recommissioning

Spring period
Ramp to 3.5 TeV

Collisions on March, 24!

2 bunches per beam
$6 \cdot 10^{9}$ protons/bunch
$5 \cdot 10^{27}$ cm^{-2} s^{-1} luminosity

Summertime
25 bunches per beam
10^{11} protons/bunch
10^{30} cm^{-2} s^{-1} luminosity

1 MJoule stored energy

Autumn period
368 bunches per beam
$6 \cdot 10^{11}$ protons/bunch
$2.1 \cdot 10^{32}$ cm^{-2} s^{-1} luminosity

20 MJoule stored energy

Design goal (from 2013)

2835 bunches per beam
10^{11} protons/bunch at 14TeV
25 ns bunch spacing
10^{34} cm^{-2} s^{-1} luminosity

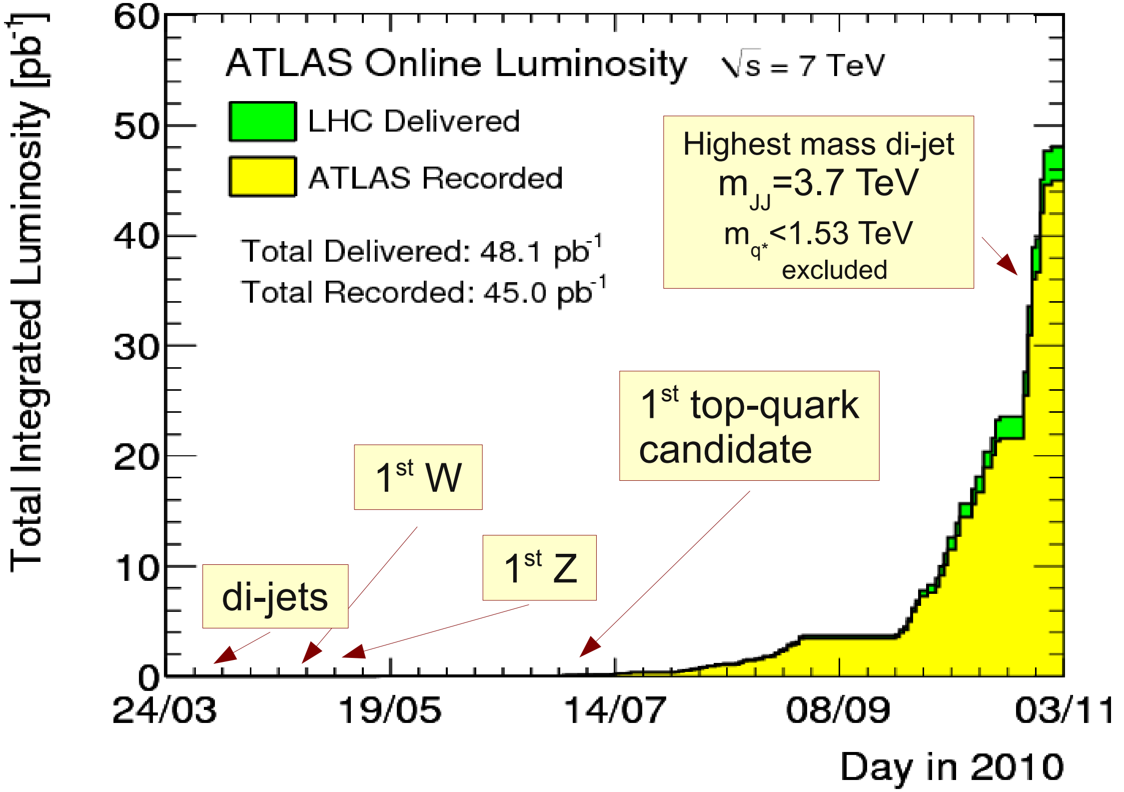
335 MJoule stored energy

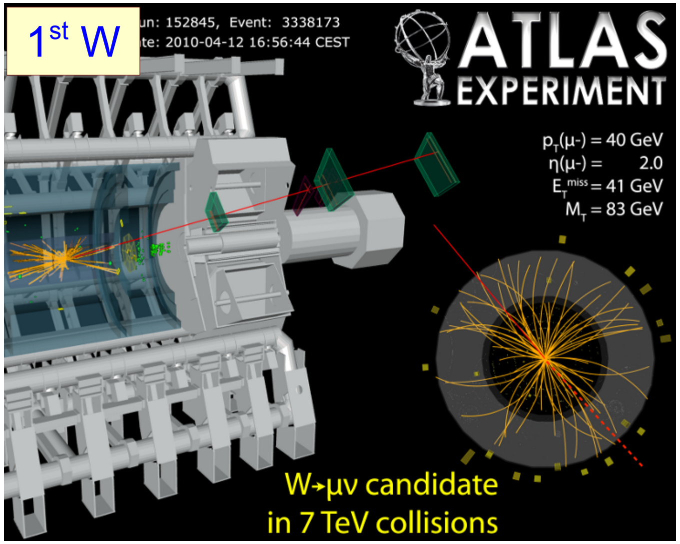
ATLAS in 2010 - proton-proton 7 TeV period

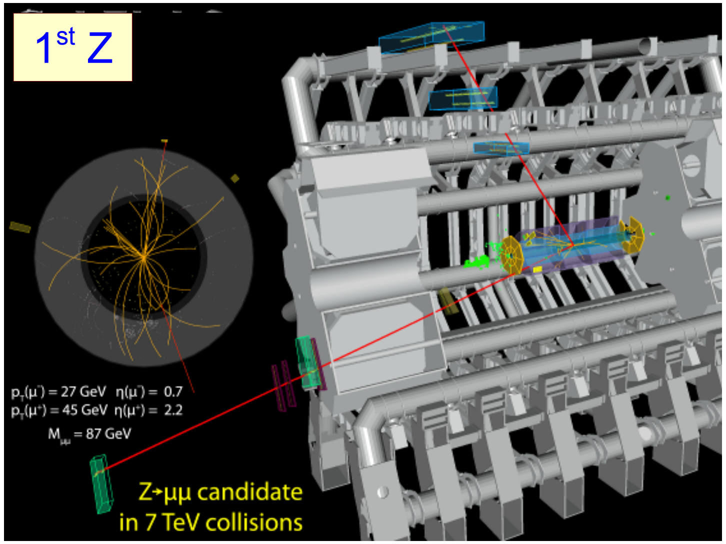
- Integrated luminosity: 48.1 pb^{-1}
  ATLAS data taking efficiency 92%
- 88M channels in whole ATLAS
  97% channels are in operation
- Total fraction of good quality data (green "traffic light")

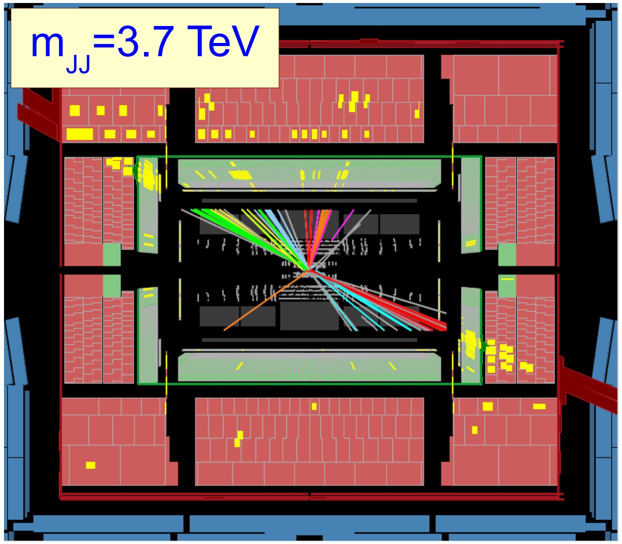
Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	TGC	CSC
96.7	97.5	100	93.8	98.8	99.0	99.7	98.6	98.5	98.6	98.5

can be even improved offline









Heavy Ions Period

November, 7 - first collisions of lead ions

$E_{beam} = 3.5$ TeV $\times$ Z = 287 TeV, $\sqrt{s_{NN}} = 2.76$ TeV

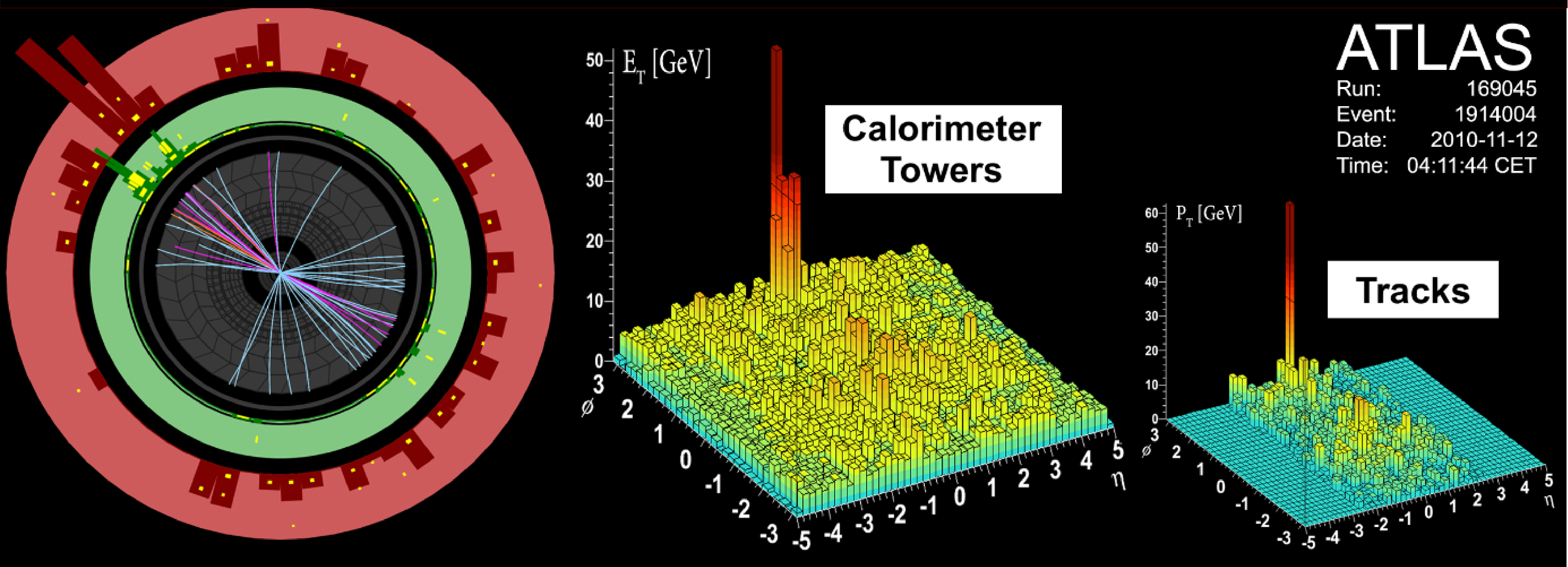
Max peak $\mathscr{L} = 1.3 \cdot 10^{24}$ cm^{-2} s^{-1}
5 bunches/beam
Total integrated 5.63 μb^{-1}

Why heavy ions?

- Collisions are expected to produce quark-gluon plasma
  - jet can be completely absorbed by the medium ("jet quenching" effect)
- Can be observed as highly unbalanced di-jets (J.D. Bjorken, *FERMILAB-PUB-82-059-THY, 1982*)

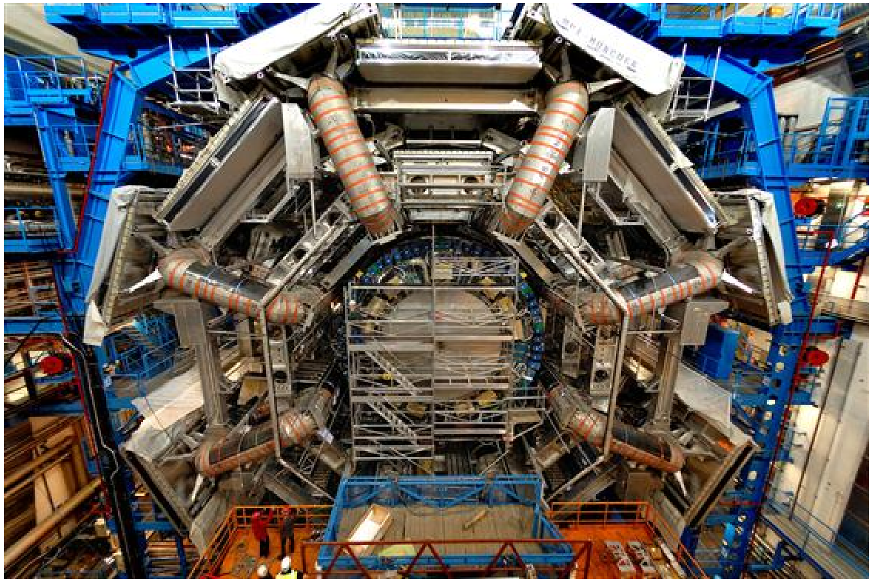
CERN-PH-EP-2010-062: Observation of a centrality dependent di-jet asymmetry

A highly asymmetric di-jet event with one jet with Et>100 GeV and no evident recoiling jet

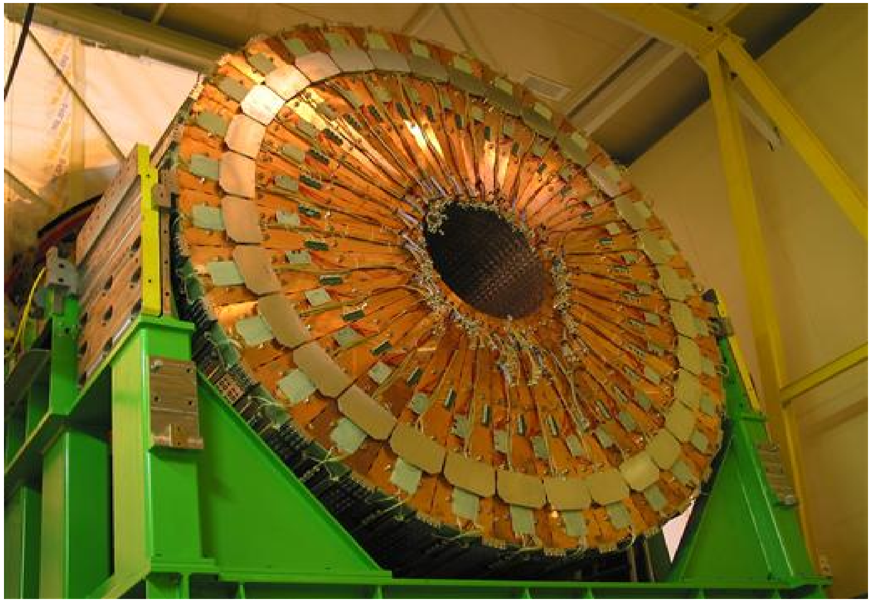


ATLAS at MPP

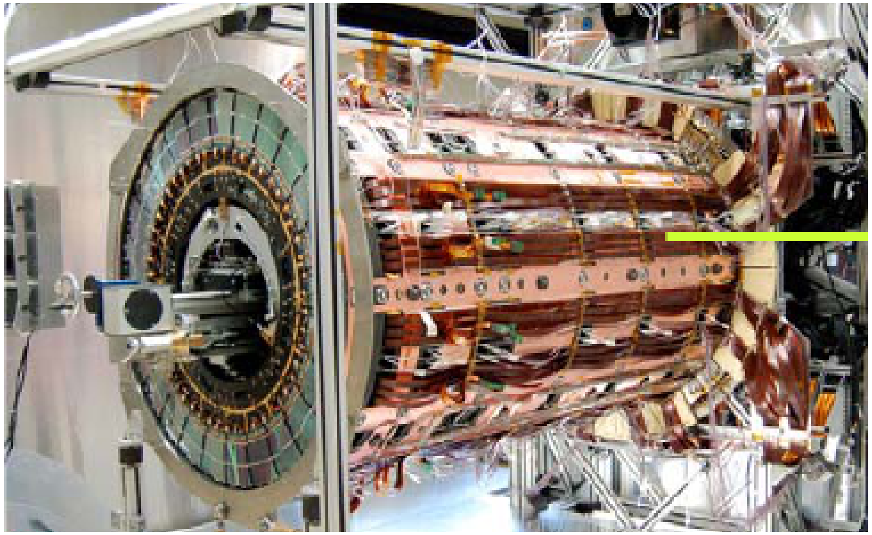
Muon Drift Tube chambers

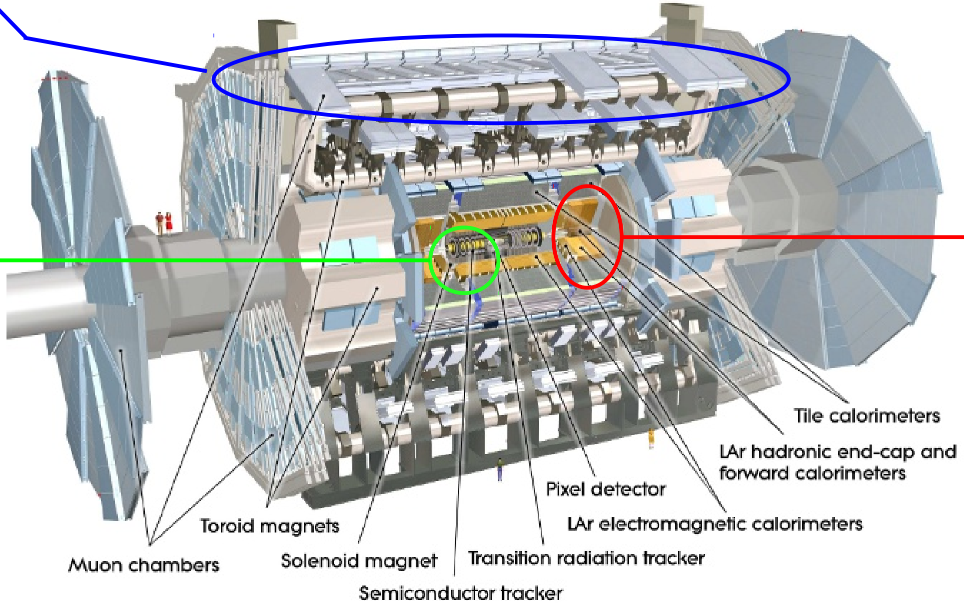


Hadron Endcap Calorimeter



Semiconductor Central Tracker

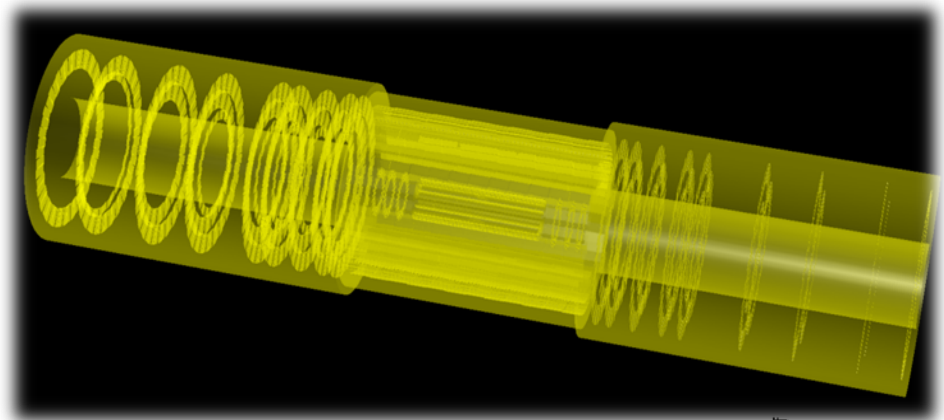




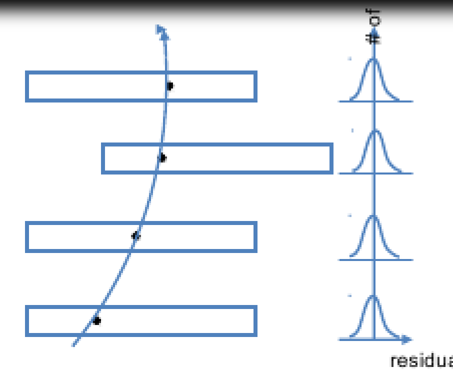
Inner Tracker Alignment

Measurements of relative positions of 5800 silicon strip and pixel detector modules

- Performed with particle tracks (10 μm accuracy) after successful ID pre-alignment with cosmic data
- Run subsequently at different levels of detector granularity
- Three different approaches: global, local (MPP), robust

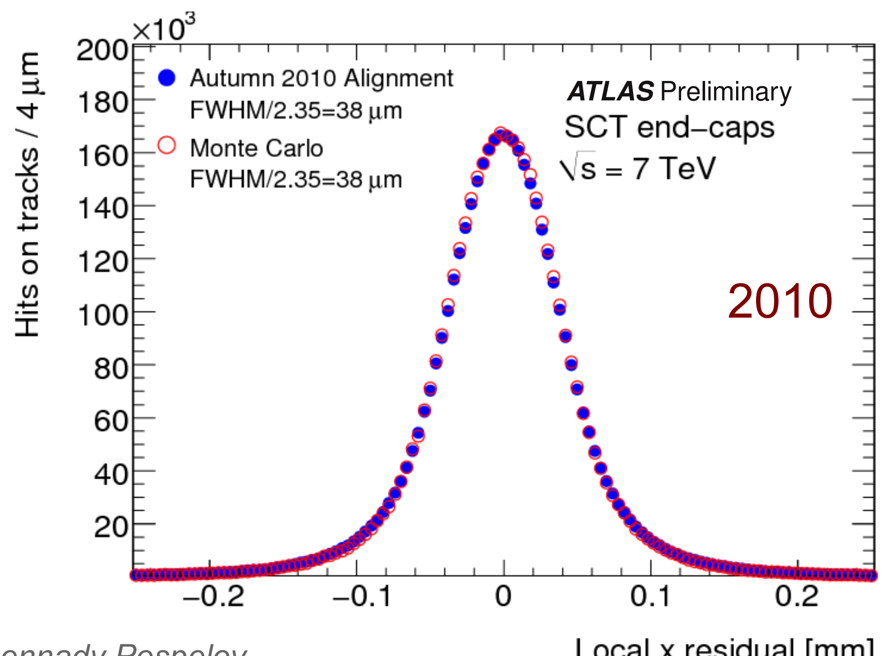


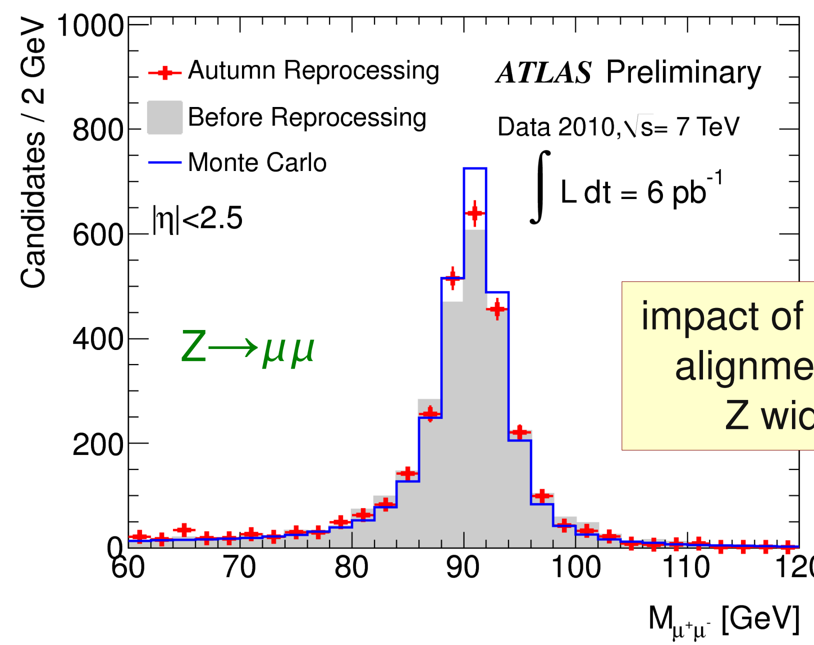
Residual based iterative χ^2 approach



Progress in width of the track residual distribution

75μm (cosmic in 2008) $\longrightarrow$ 40μm(2009) $\longrightarrow$ 38μm (2010)



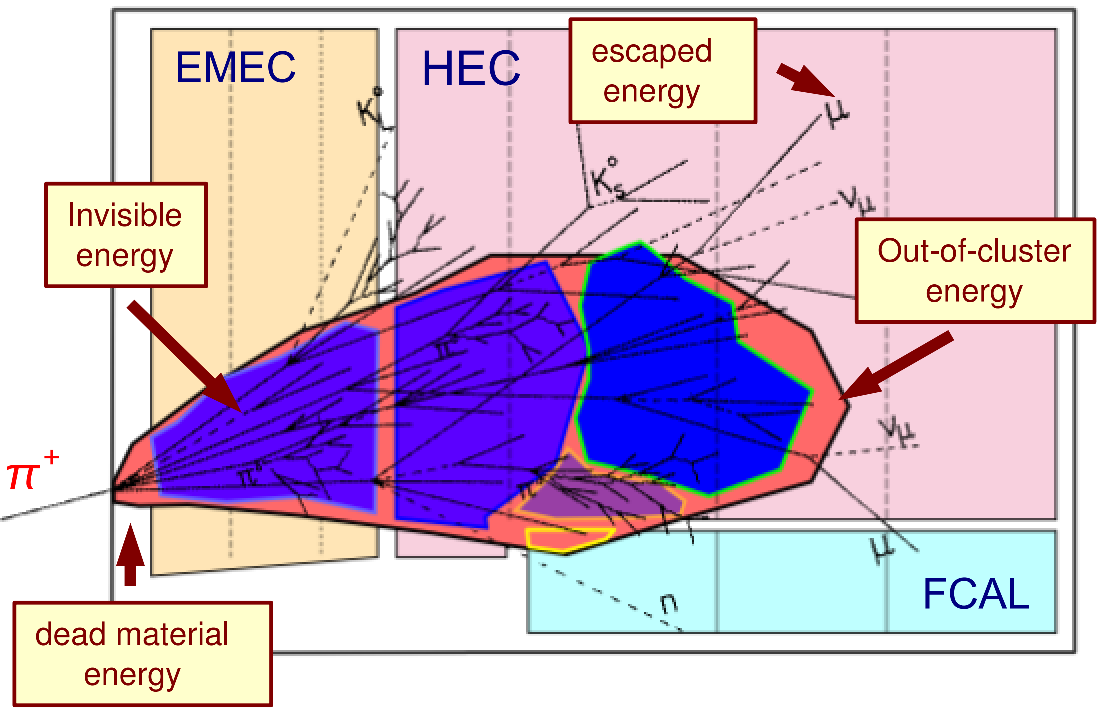


impact of tracker alignment on Z width

Hadronic Shower and Jet Calibration

- The aim is to have correct response to hadrons and electrons in all physics channels

ATLAS calorimeter doesn't account for invisible and escaped energy (non-compensation)



- 10 GeV charged pion:
  - O(60%) - reconstructed at em scale
  - O(40%) - invisible, out-of-cluster, escaped, dead material energy components to compensate

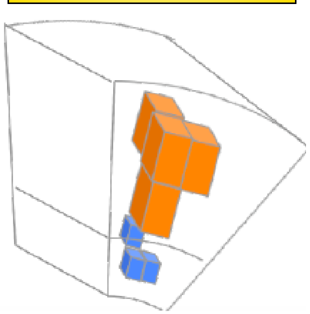
Local Hadronic Calibration

- calibrate calorimeter signal prior to jet finding
- long term program initiated and lead by MPP

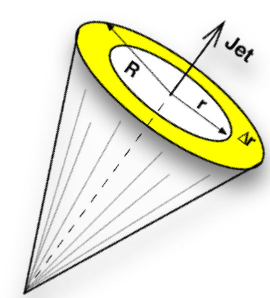
Advantage

- Common signal base for all hadronic final states

calorimeter cells at *em* scale → 3D topological clusters at *em* scale → Classification *em* or *had*? → Software Compensation: 1. hadronic weighting 2. out-of-cluster correction 3. dead material correction → 3D topological clusters particle scale → Jet Finding → Jets



$\lambda_{cluster}, \rho_{cluster}$?



Hadronic Shower and Jet Calibration

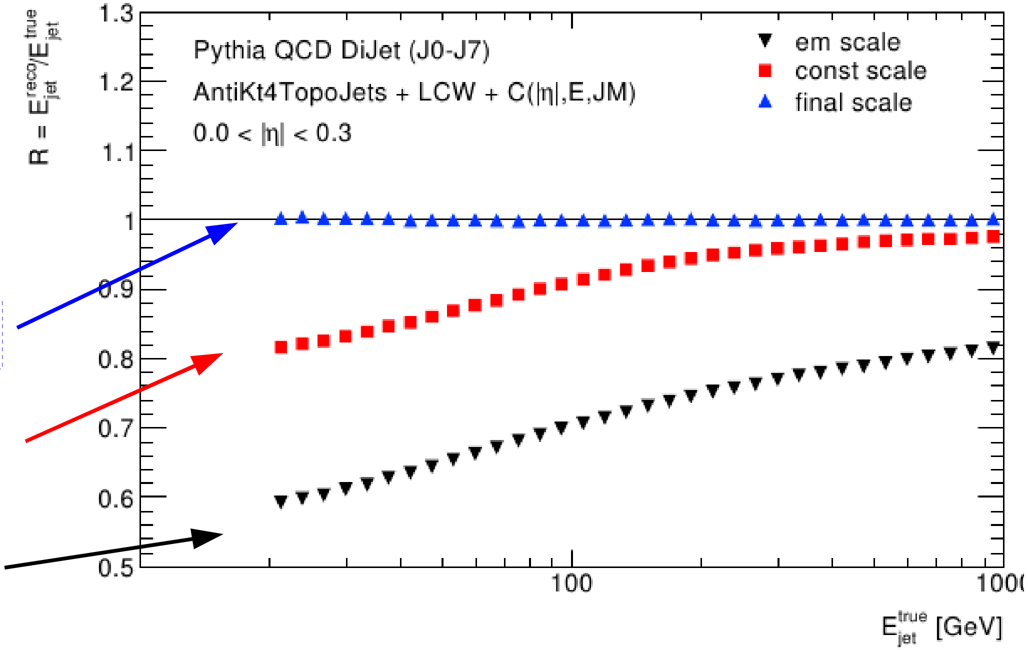
Closure tests

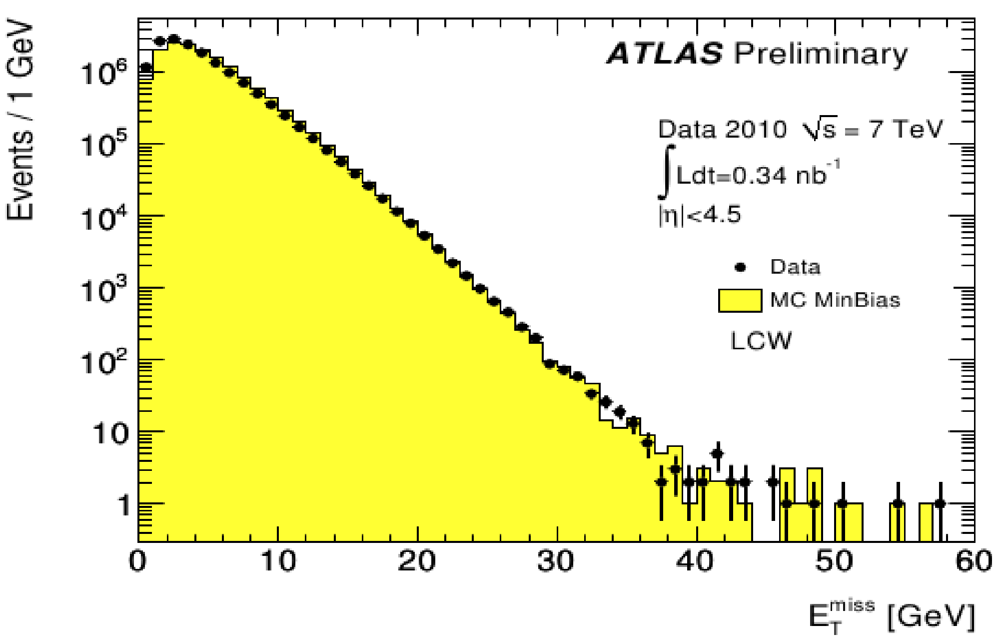
- The ratio of reconstructed jet energy to the energy of matched truth jet before and after calibration

Reco jet corrected for particles lost before calorimeter

Reco jet corrected for *had* compensation, out-of-cluster and dead material losses

Reconstructed jet at *em* scale



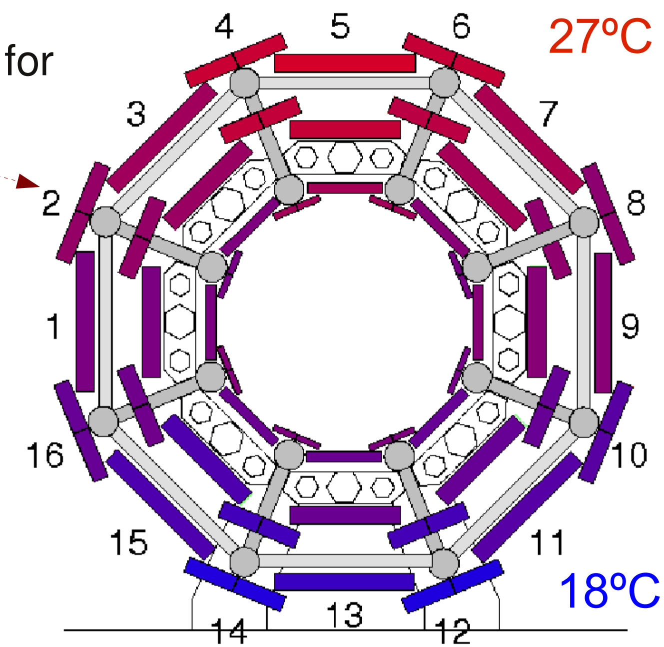


- Like for jets hadronically calibrated clusters are used for missing E_T
  - missing E_T distribution in √s=7 TeV data and MC
  - good agreement, no extra tails
- First estimation of missing E_T resolution

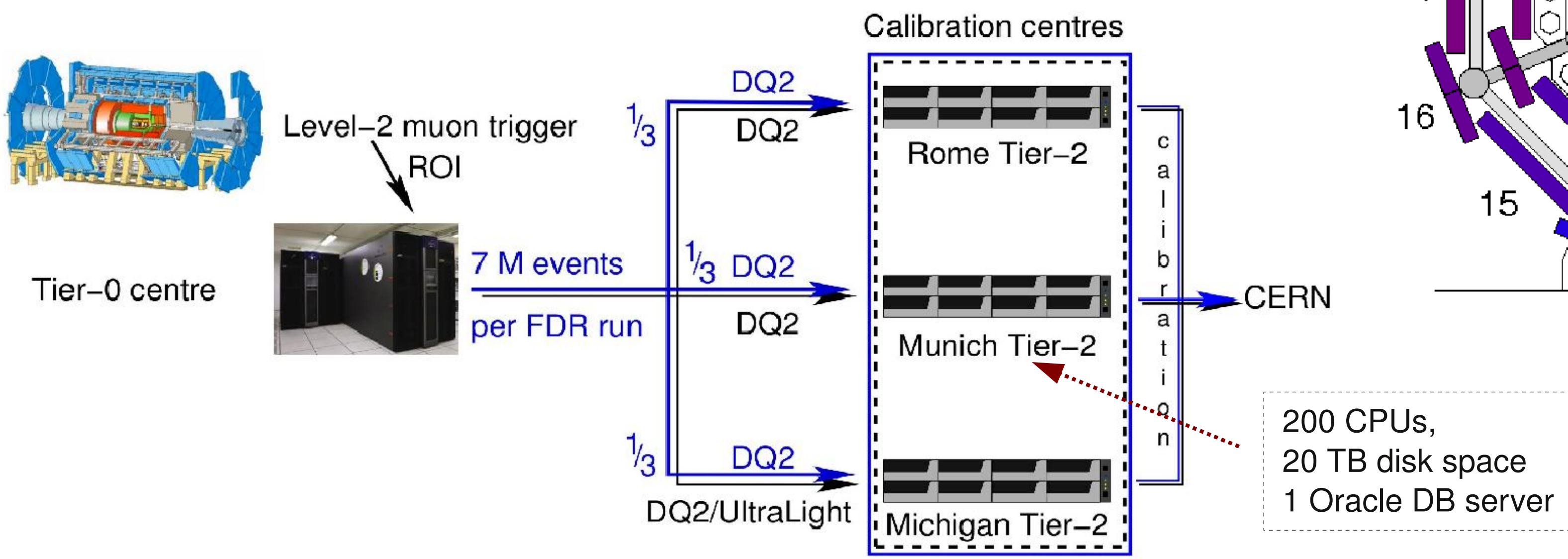
$$\sigma(E_x^{miss}, E_y^{miss}) = 0.5 \times \sqrt{\sum E_T}$$

Muon Spectrometer: calibration of drift-tube chambers

- Muon precision drift tube chambers provide spatial resolution of 35μm to achieve 10% momentum resolution at 1TeV
- Space drift-time calibration r(t) is required for 1170 chambers to account for radiation background, magnetic field, temperature in the cavern



- Muon Calibration&Alignment Computing center:

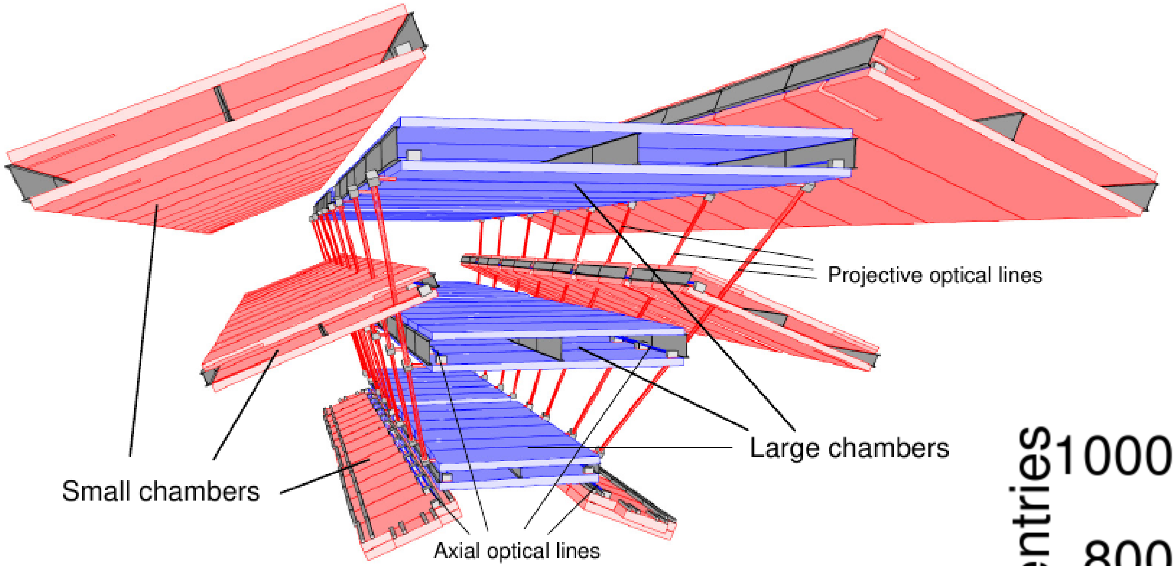


See talk of Stefan Kluth

Calibration strategy:

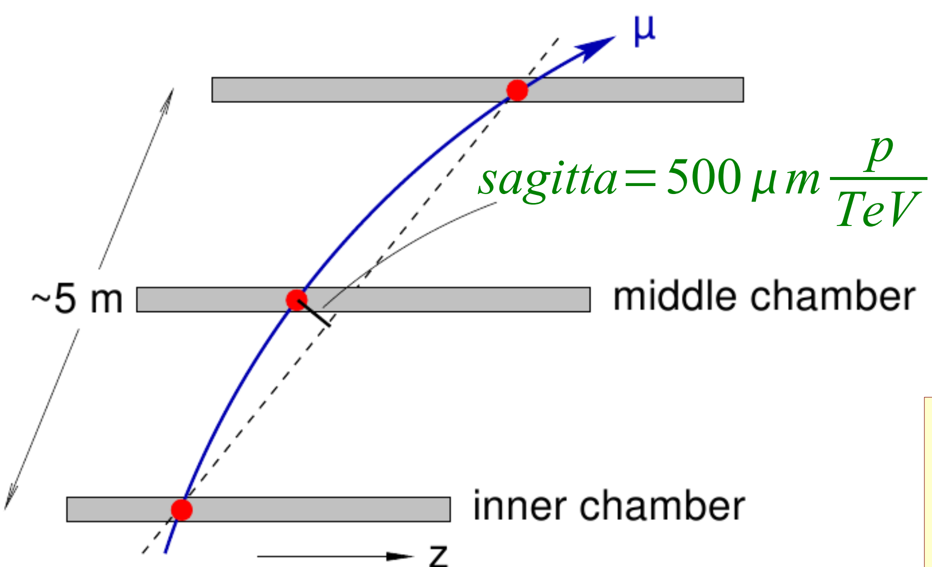
- Acquire 1 kHz single muon stream from level-2 trigger
- Send this data to Michigan, Munich and Rome
- Determine the space drift-time relations by minimizing track residuals in MDT chambers
- Update the database

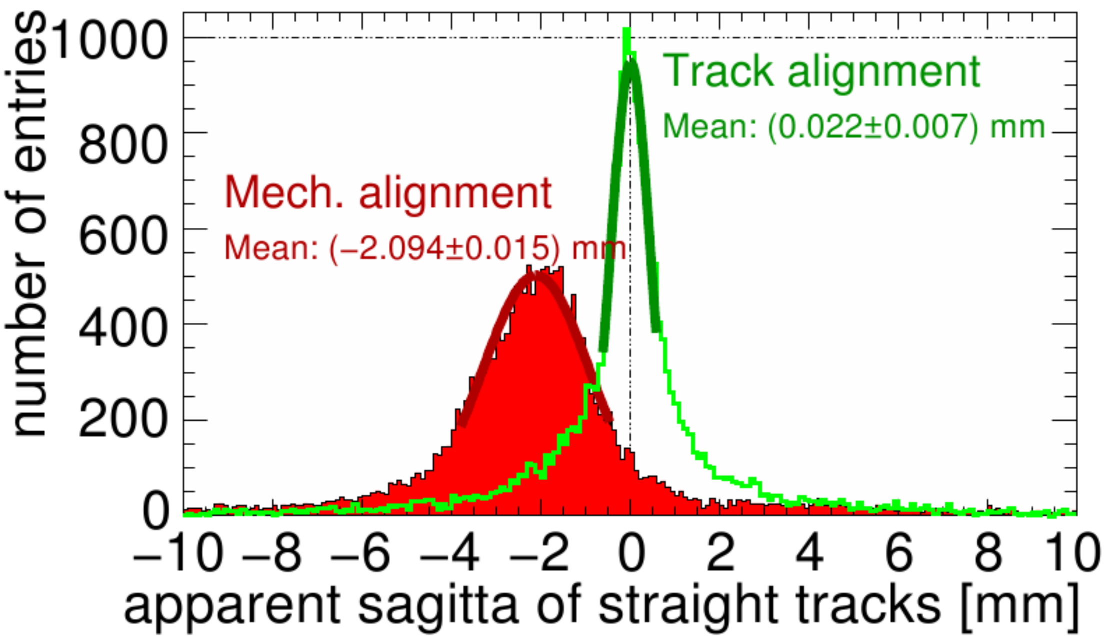
Muon Spectrometer: alignment with tracks



Alignment concept:

- Movement of chambers are monitored with few μm precision by a system of optical sensors
- Initial relative position of the chambers are measured with straight muon tracks (without magnetic field)

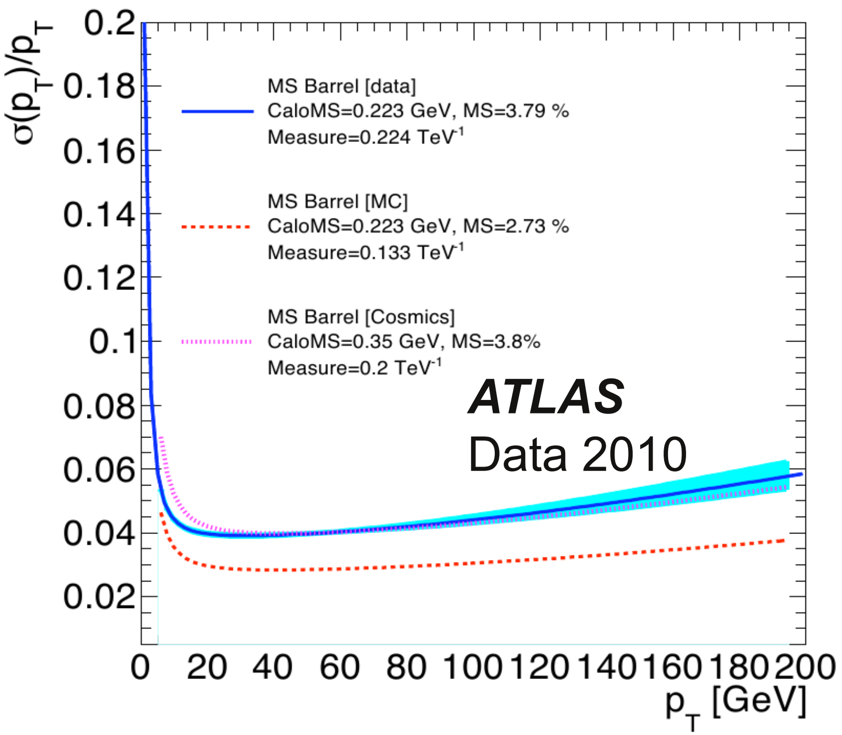




Sagitta resolution (width of the distribution) is 100μm at 1 TeV, 200μm at 100 GeV

- correspond to momentum resolution 20% at 1TeV

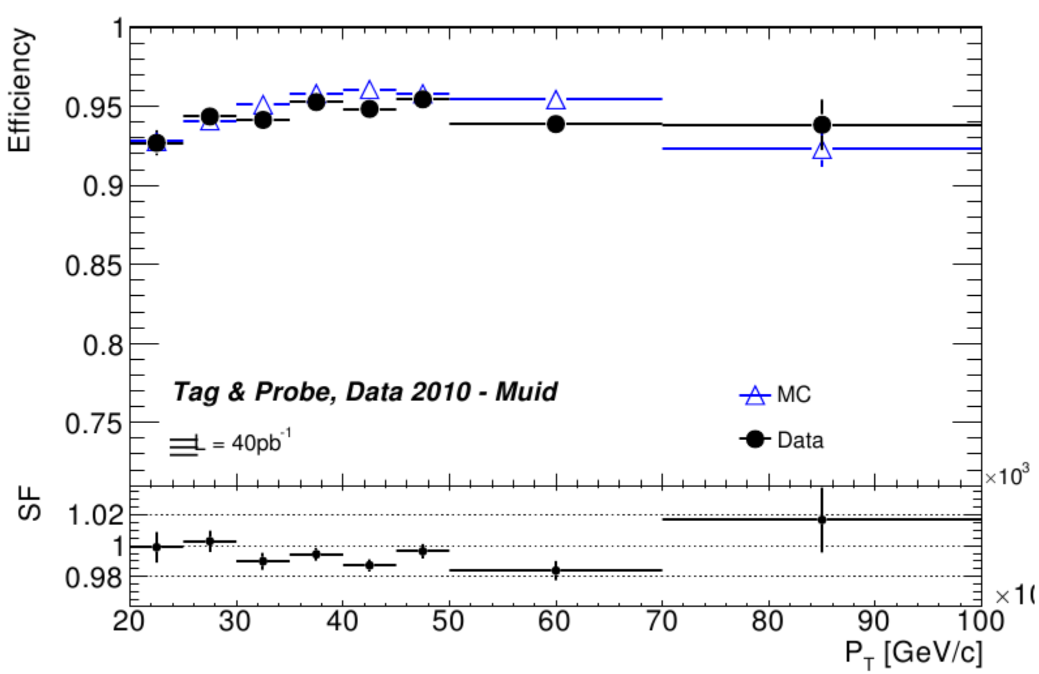
Muon Spectrometer: performance



- Momentum resolution measurement derived from width of J/ψ and Z mass peaks in agreement with cosmic ray data
  - momentum resolution of 20% at 1 TeV
  - design resolution 10% only after calibration run with pp collisions with no magnetic field (planned for 2011)

- Muon efficiency measurements using $Z \rightarrow \mu\mu$ decays
  - Require pair of muon and a track in the inner detector, check if track was identified as muon

Measured and predicted muon identification efficiencies agrees nicely within 1%



LHC data analysis

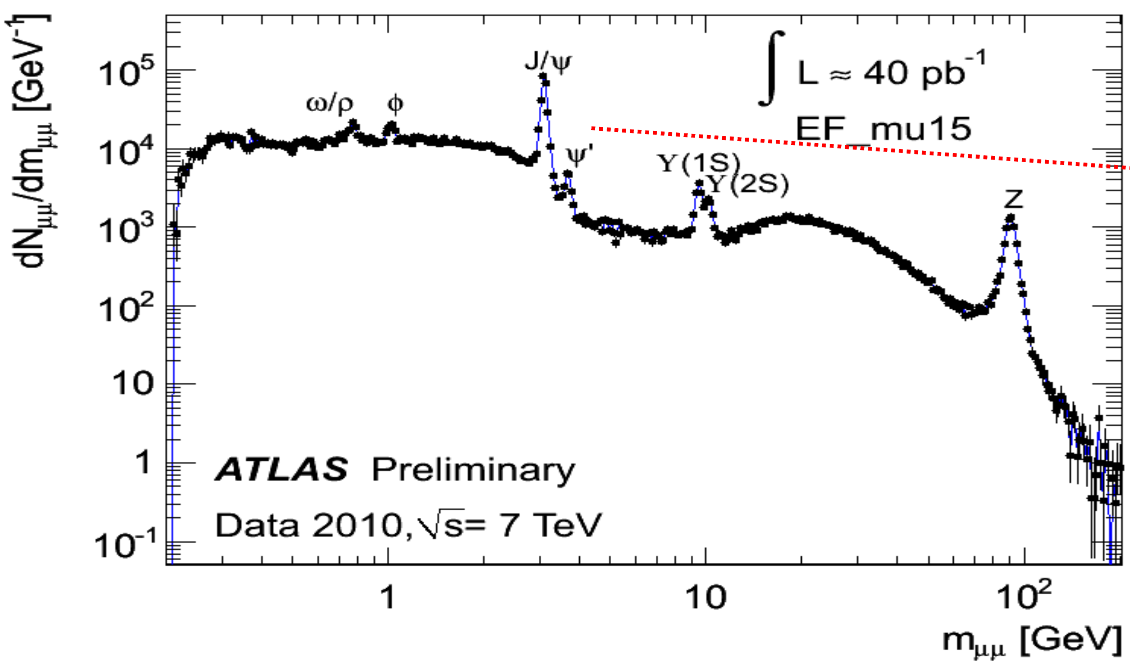
- ATLAS has recorded ~45 pb^{-1} of data at $\sqrt{s}$ = 7 TeV
- First round of physics analysis in ATLAS is just about all the physics of the last half-century
  - based mainly on several pb^{-1} of integrated luminosity, full update is expected for Spring/Summer Conferences 2011

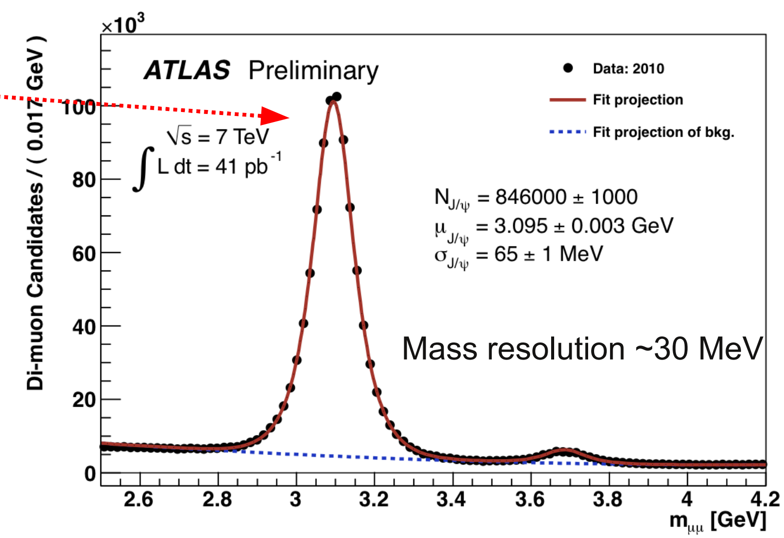
MPP ATLAS group activity

- Standard model physics (electroweak, QCD) in early data taking phase
- Precision top quark measurements
- Search for the Higgs boson in the standard model and beyond
- Search for supersymmetry and for beyond standard model physics

Dimuon mass spectrum and resonance peaks

- Observed all classic resonances
- Event selection:
  - L1_muon trigger, $P_T\ \mu 1(2) > 4(2.5)$ GeV, opposite charge pair
- J/Ψ is one of the first “candles” for detector commissioning and early physics
  - large sample of low-pt muons to study trigger and identification efficiency, resolution and absolute moment scale in the few GeV range
  - Use other candles to establish points along momentum scale





$m_{\mu\mu}$ spanned over ~3 orders, several familiar resonances

J/Ψ mass is in the agreement with PDG values

Electroweak gauge boson production cross section

- Electroweak gauge boson W and Z production at 7 TeV
  - Among dominant backgrounds to search for New Physics

$W \rightarrow l\nu$

Transverse mass m_T

$$m_T = \sqrt{2\, p_T^l\, p_T^\nu (1 - \cos(\varphi^l - \varphi^\nu))}$$

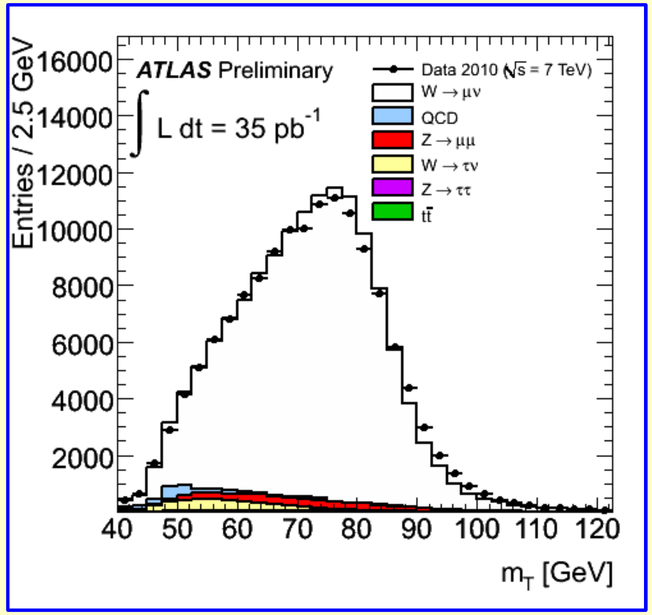
P_T lepton > 20 GeV

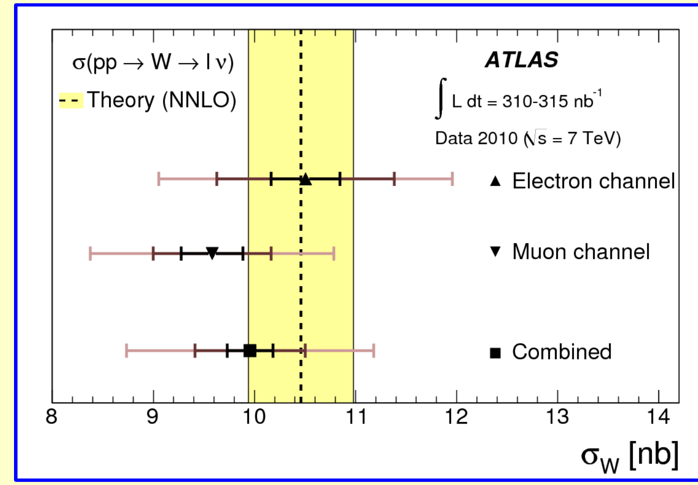
Isolated muon $|Z_\mu - Z_{vtx}| < 1$ cm

$E_T$miss > 25 GeV

m_T > 40 GeV

Background: QCD jets





stat syst lumi

$\sigma_W BR(W \rightarrow l\nu) = (9.96 \pm 0.23 \pm 0.50 \pm 1.10)$ nb

$Z \rightarrow ll$

Pair of opposite charged leptons

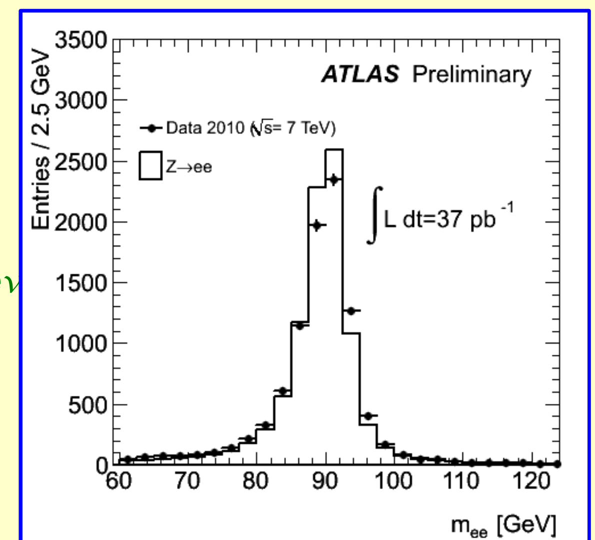
$|\Delta p_T(\text{ID-MS})| < 15$ GeV

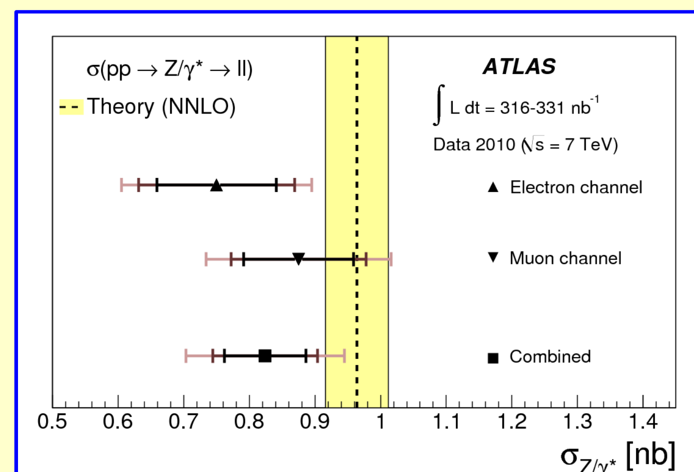
66 GeV < m_{ll} < 116 GeV

Background: QCD, $ZZ \rightarrow \tau\tau$ $W \rightarrow e\nu$

$M(Z_{ee}) = 90.9 \pm 0.3$

$M(Z_{\mu\mu}) = 90.8 \pm 0.3$





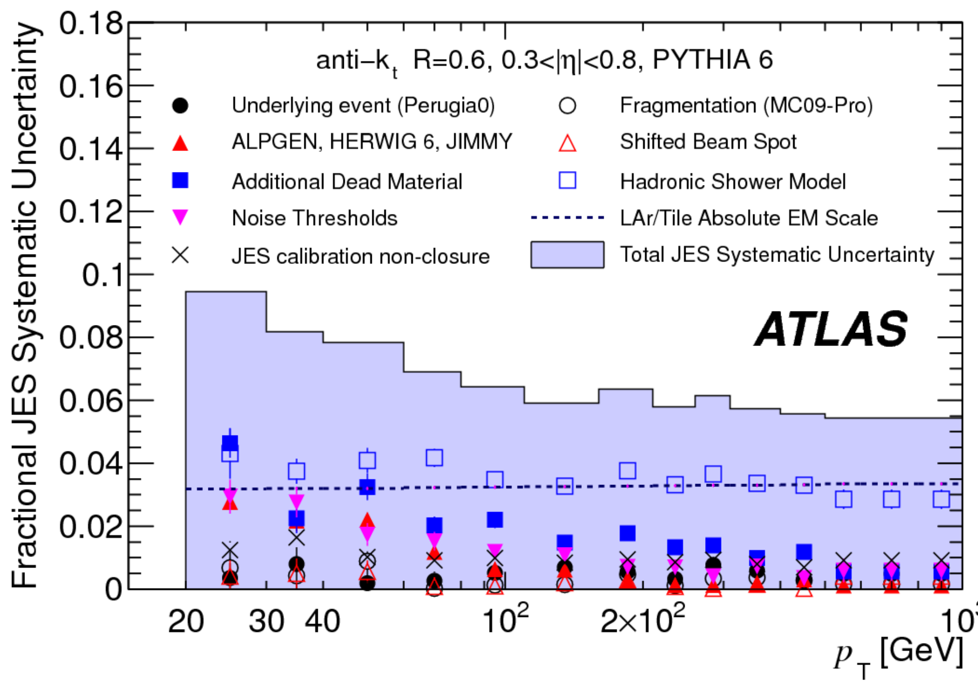
stat syst lumi

$\sigma_{\gamma Z} BR(\gamma/Z \rightarrow ll) = (0.82 \pm 0.06 \pm 0.05 \pm 0.09)$ nb

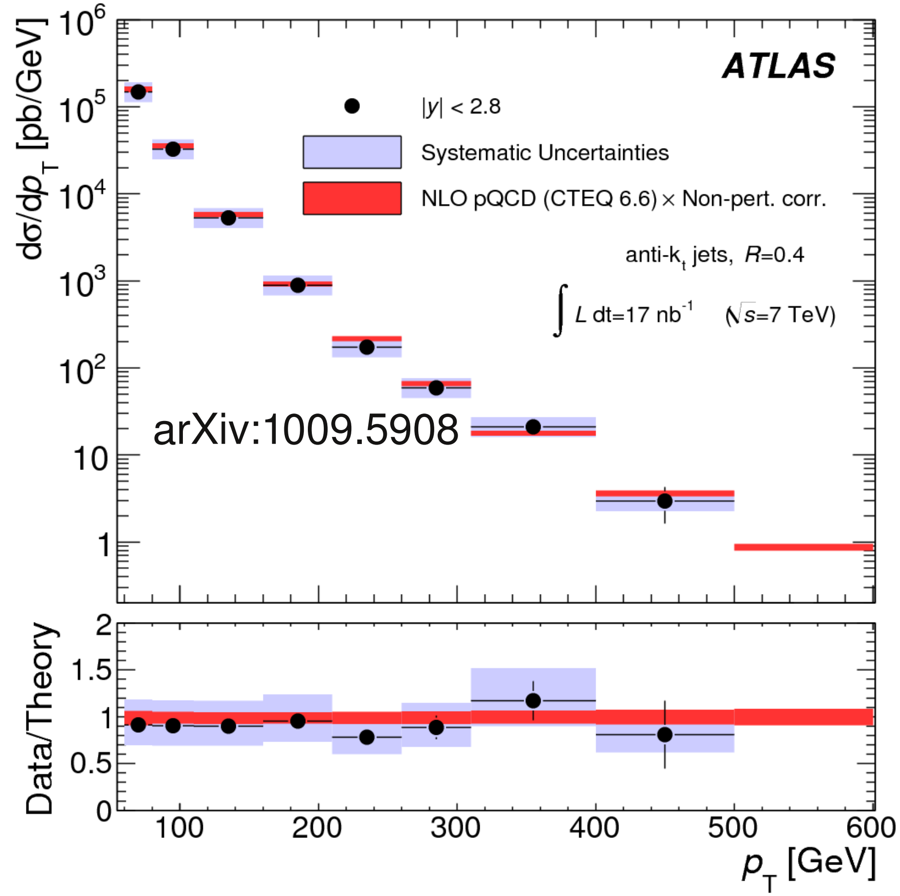
Inclusive Jet cross section

17 nb^{-1}, 7 TeV

- Using anti-Kt algorithm with R=0.4
- Measured jets corrected to particle level using parton shower MC (Pythia, Herwig)
- Results compared with NLO QCD prediction after correction for hadronization and underlying event
- Experimental uncertainty ~40%
  - Dominated by jet energy scale (JES)
  - Luminosity (uncertainty ~10%)



Inclusive jet differential cross section as a function of jet p_T integrated over full region of $|\eta|<2.8$



Dominant contributions to jet energy scale uncertainty

- Hadronic shower model
- Electromagnetic scale uncertainty
- Material description

Top Quark Physics

Tevatron	√s	1.8 TeV		
	$\sigma(p\bar{p}\rightarrow t\bar{t})$	~7pb		
LHC	√s	7 TeV	10 TeV	14 TeV
	$\sigma(pp\rightarrow t\bar{t})$	~160pb	~400pb	880pb

m_{top}=173.1 ±0.6(stat)±1.1(syst)

x20 times Tevatron

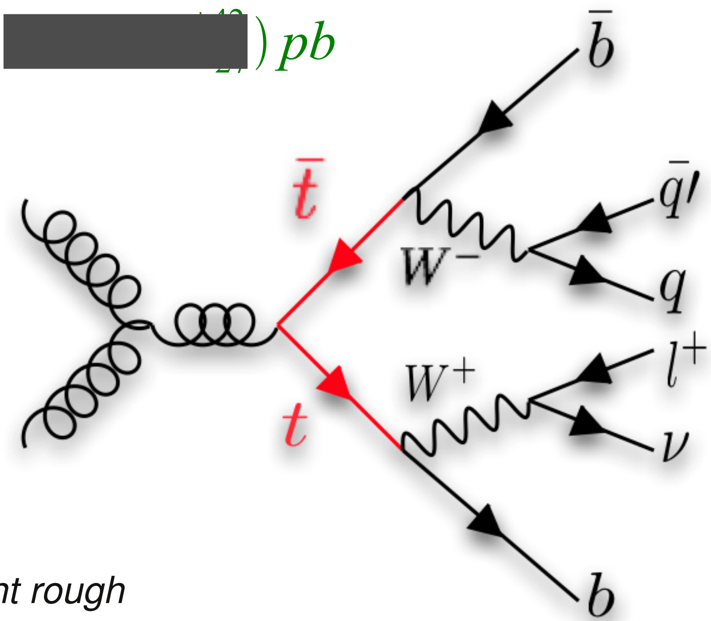
Uncertainty will be soon dominated by systematic

$\sigma_{t\bar{t}}$=([redacted]) pb

"single leptons + jets" early discovery channel

$t\bar{t} \rightarrow bWbW \rightarrow bl\nu\ bjj \quad (Br = 33\%,\ l = e,\mu)$

One top pair is decaying every 20 nb^{-1} of data



Measurement of top quark properties in ATLAS requires good understanding of full detector performance

Lepton identification	*mis-identification ~10^{-5}*
ET miss	*uncertainty 8 GeV*
Jet energy scale	*uncertainty 7%*
B-tagging	*~50% b-tag efficiency*

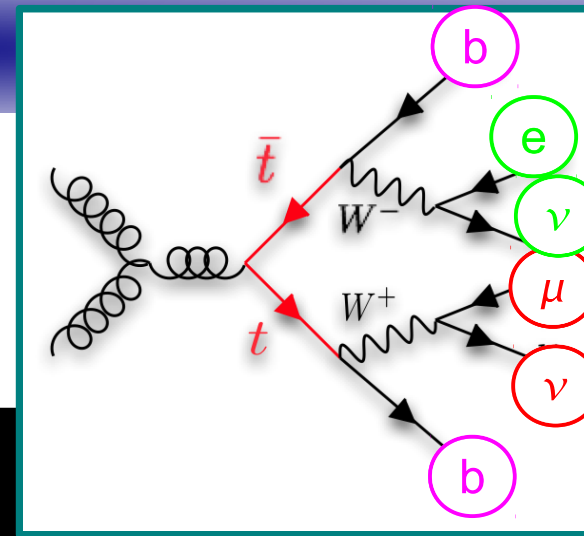
current rough estimation

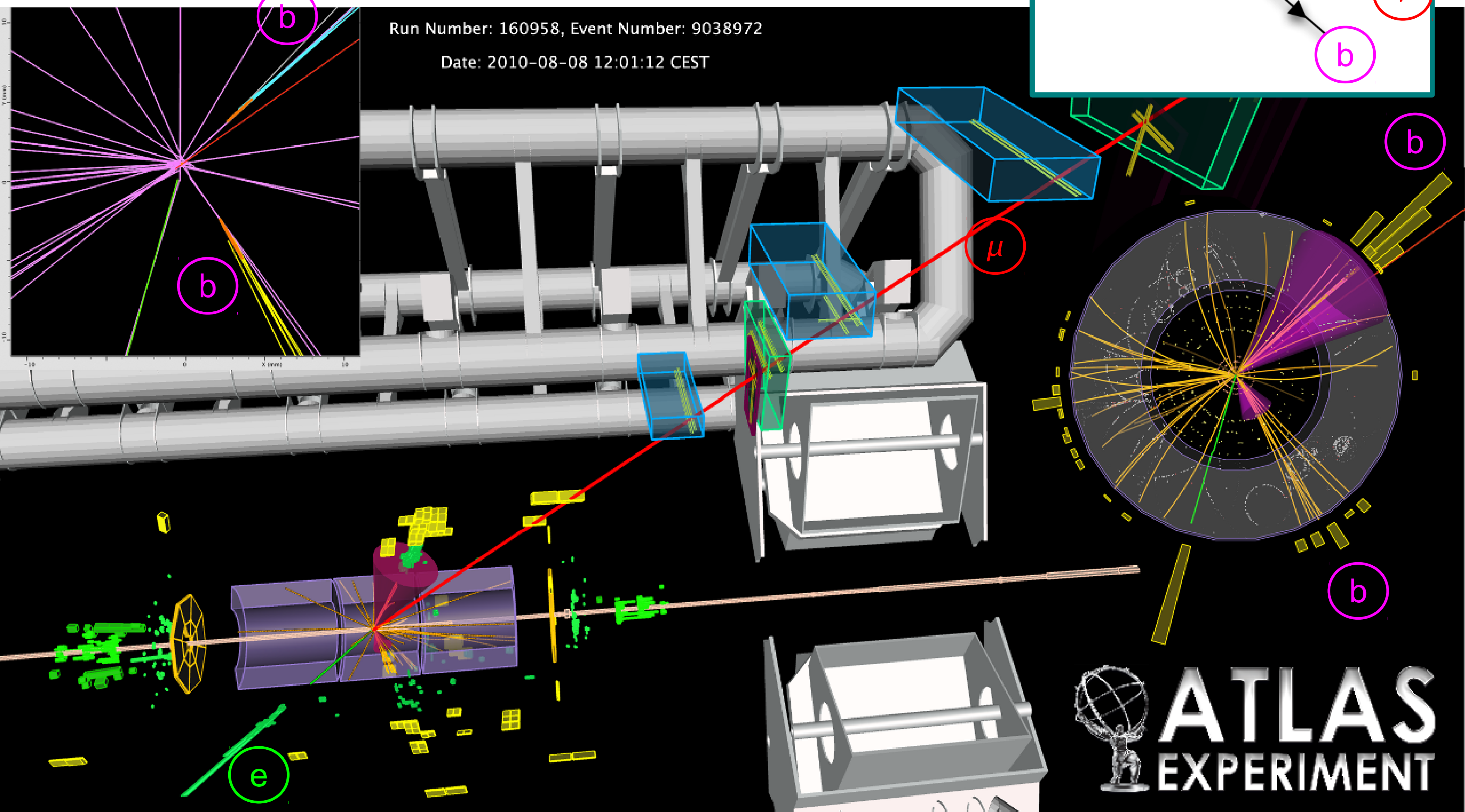
Several methods applicable for early top mass measurements are investigated at MPP

- To increase signal/background ratio
- To decrease impact of jet uncertainty
- To evaluate background from the data

Top in Data

- Already at the end of May we started to observe events like this
  - event display of a top pair e-mu dilepton candidate with two b-tagged jets.

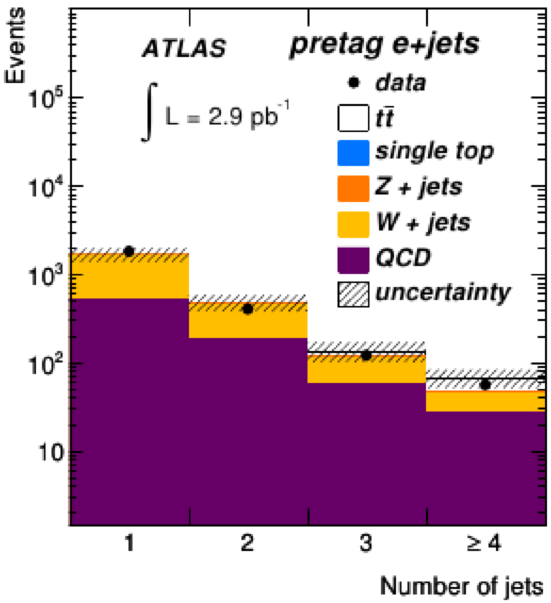


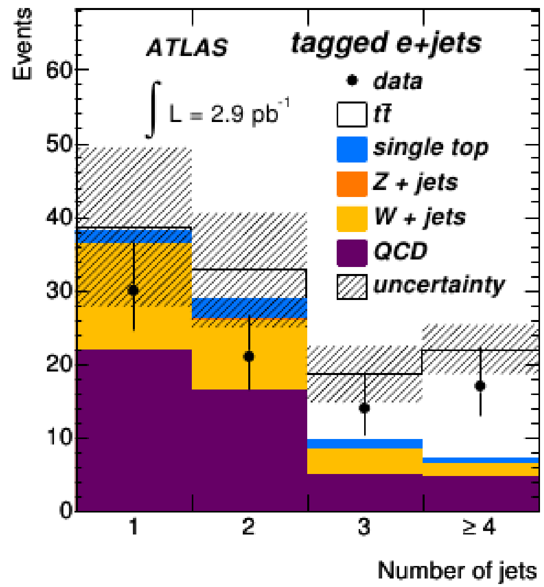


Top in Data

- Top quark pair production cross section with 2.9 pb^{-1} in lepton + jets final state

arXiv:1012.1792





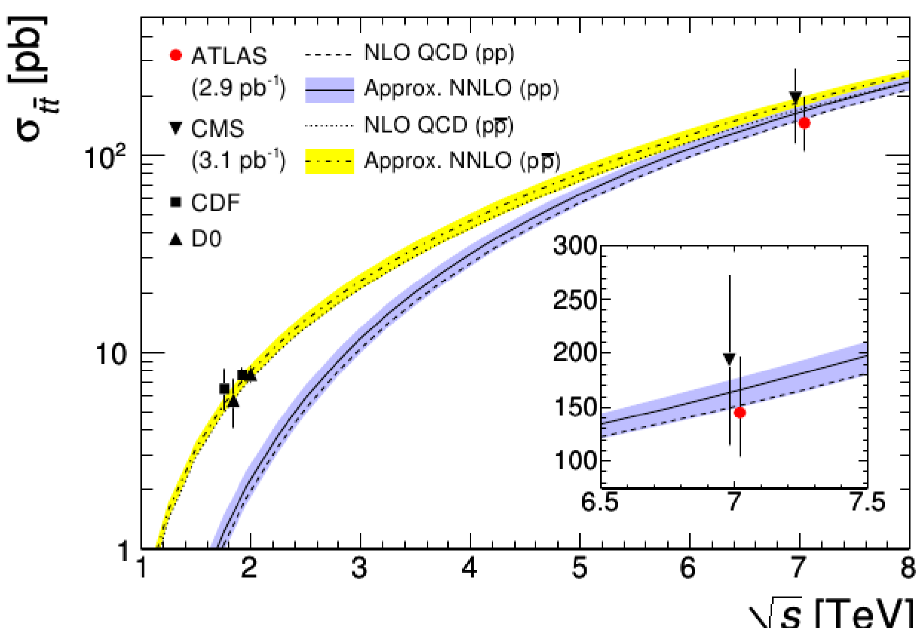
Jet multiplicity distributions in electron + jets channel:

- missing $E_T > 20$ GeV
- One electron $P_T>20$ GeV
- At least one jet $P_T>20$ GeV
- Before(left) and after(right) b-tagging

Excess of events with ≥4 jets after applying of b-tagging means appearance of t.

- Selected $t\bar{t}$ candidate:
  - 37 single lepton events (e/μ)
  - 9 dilepton events ($ee+e\mu+\mu\mu$)
  - 12.5±5.1 events - background contribution W+jets+QCD estimated from data

$$\sigma_{t\bar{t}} = (145 \pm 31^{+42}_{-27})\ pb$$



Prospects for m_{top} with 1-d template method

Template method:

m_{top}^{reco} from $m_{top} = [160, 170, 172.5, 180, 190]\, GeV$

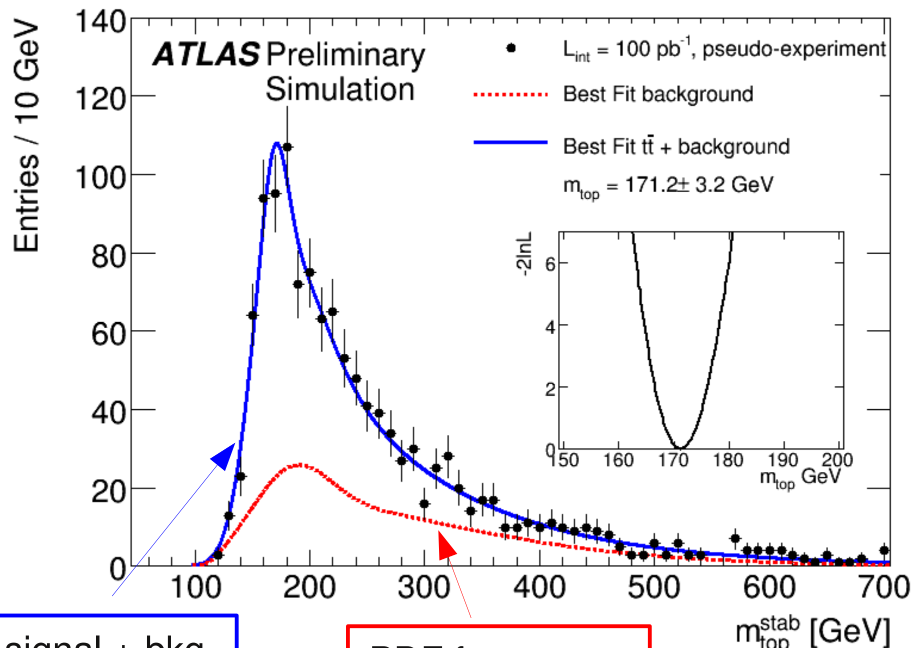
- Parametrization of the signals by a single PDF depending on m_{top}
- Background PDF is obtained from the sum of all background distributions (independent on m_{top})
- No b-tagging yet

- Stabilized m_{top}: $m_{top}^{stab} = \dfrac{m_{top}^{reco}}{m_W^{reco}} \times m_W$
- Predicted SM background fraction (S/B~1.4)
- Input m_{top} = 172.5 GeV, √s=10 TeV

Statistical uncertainty [GeV] as a function of $\mathscr{L}_{int}$			
	10 pb^{-1}	30 pb^{-1}	100 pb^{-1}
Electron channel	10.8 ± 3.5	7.0 ± 2.1	2.7 ± 1.3
Muon channel	9.9 ± 3.9	5.8 ± 1.5	2.8 ± 0.8

1-D: Δm_{top}(√s=10TeV, L=100pb^{-1})~ ±2 (stat) ± 4(syst) GeV

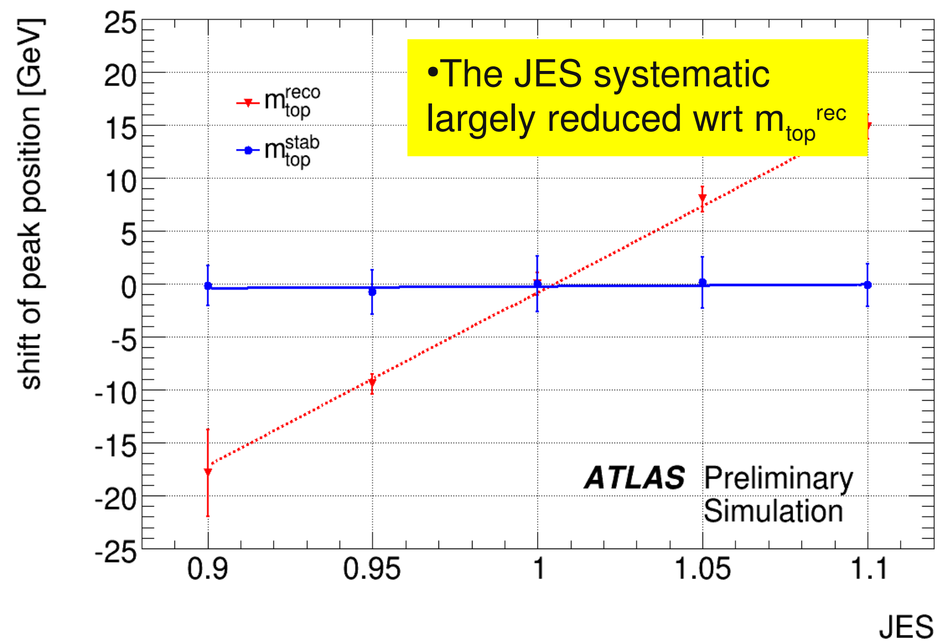
1d likelihood fit in muon channel



signal + bkg. fit to data

PDF from sums of physics bkg.

ATLAS-PHYS-PUB-2010-004

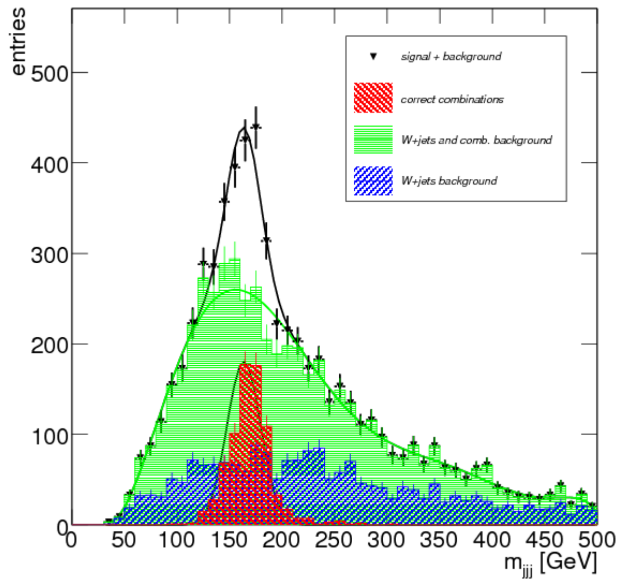


Improving on the top reconstruction

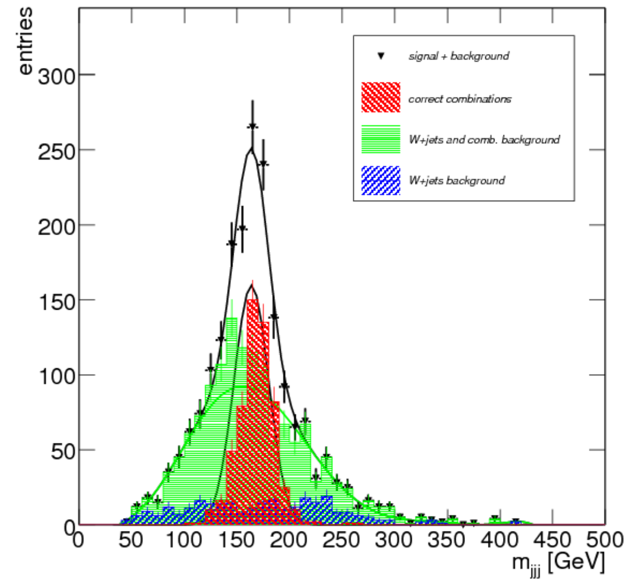
- Significant improvement of S/B with help of a multivariate analysis (Fischer discriminant) based on 7 kinematic observables

  T. Göttfert

Standard reconstruction

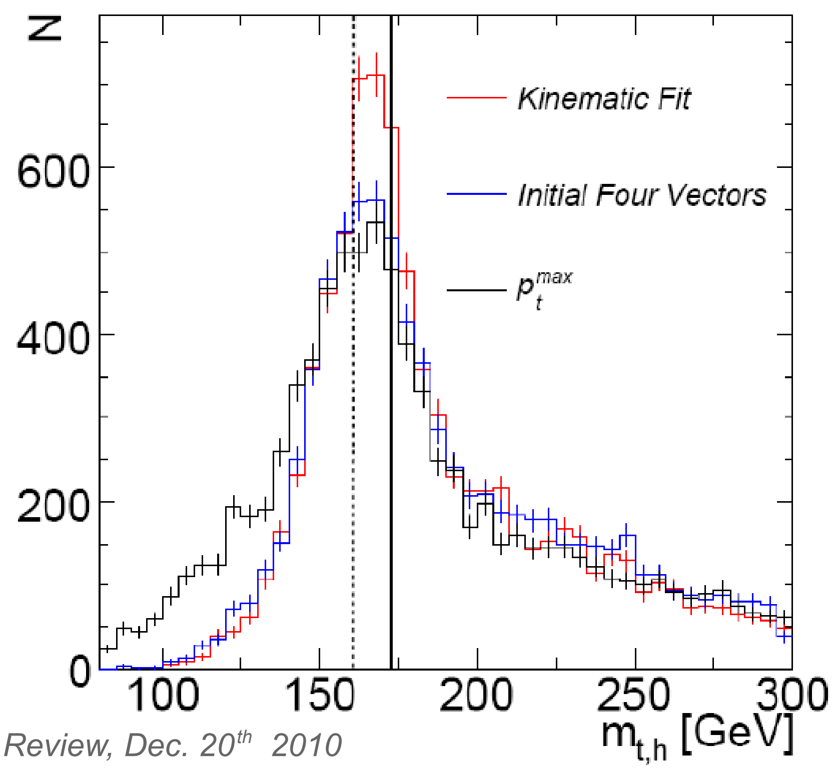


With multivariate analysis



- Significant improvement of the reconstruction of 3-jet combination from the hadronic quark candidate by using a constrained kinematical fit

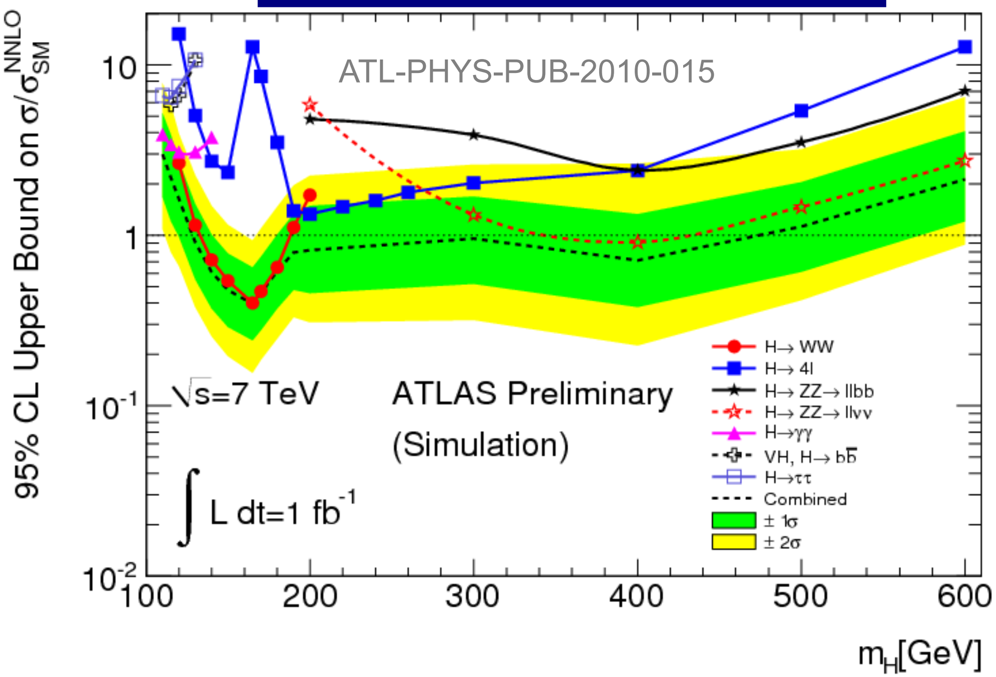
  P. Weigell



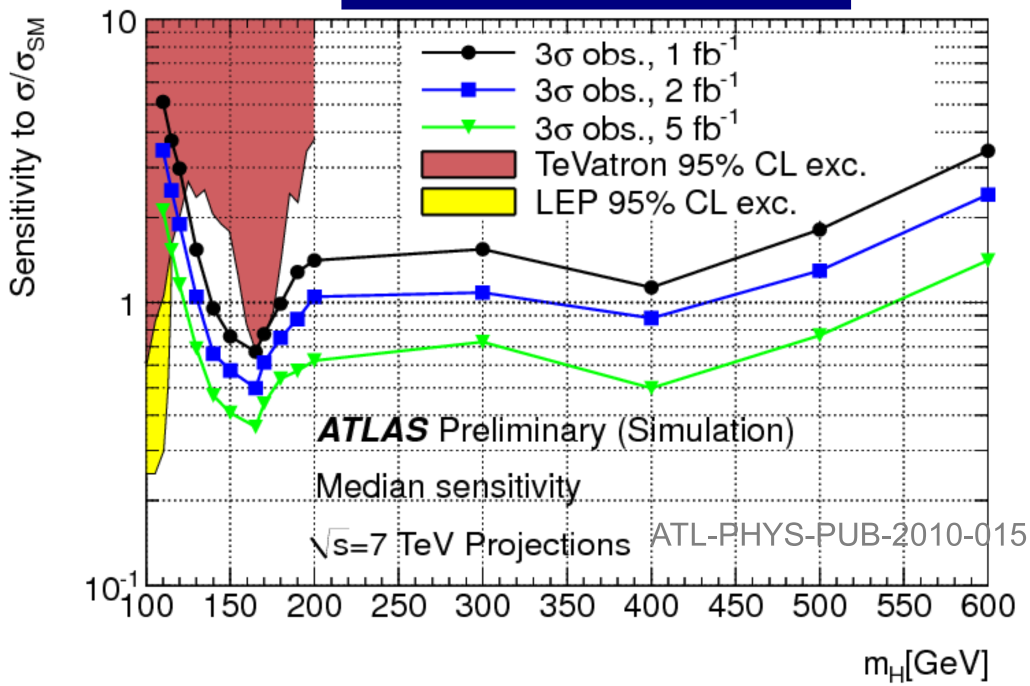
Projections for the SM Higgs Bosons

- The latest sensitivity projections for the SM Higgs boson seach at 7 TeV
  - full coverage only by combination of several channels ($H \to WW$ is dominant).

Exclusion limits at 95% C.L.



3σ evidence curves



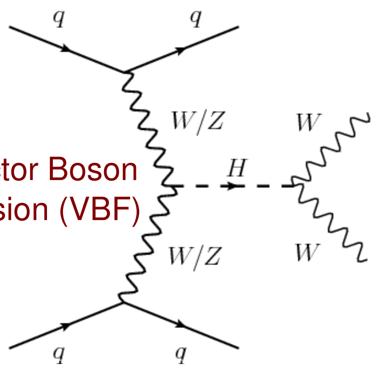
- Exclusion with 1fb^{-1} of data in the Higgs mass range from 129 GeV to 460 GeV
- 3σ evidence possible with 2fb^{-1} for Higgs masses from 131 GeV to 430 GeV

No SM Higgs exclusion or discovery is possible so far with current LHC data
However, 2011 will be the year of the Higgs!

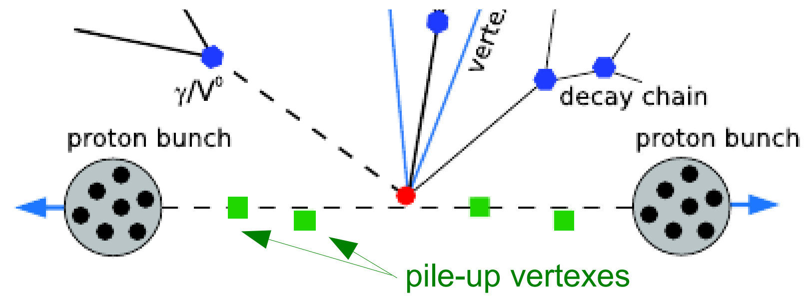
- Main MPP contributions to SM Higgs: $H \to WW \to l\nu l\nu$ and $H \to ZZ \to 4l$ channels
- Working on exclusion limits and data-driven background estimation for Winter Conferences (~35pb^{-1} of data)

SM Higgs Boson Search: (VBF) H→WW→lνlν

Vector Boson Fusion (VBF)

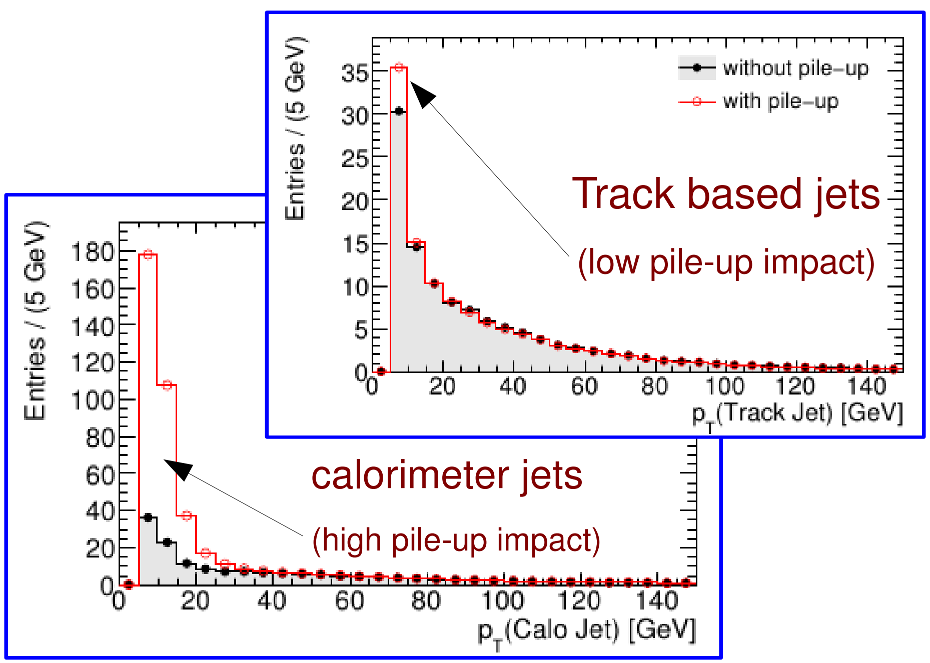


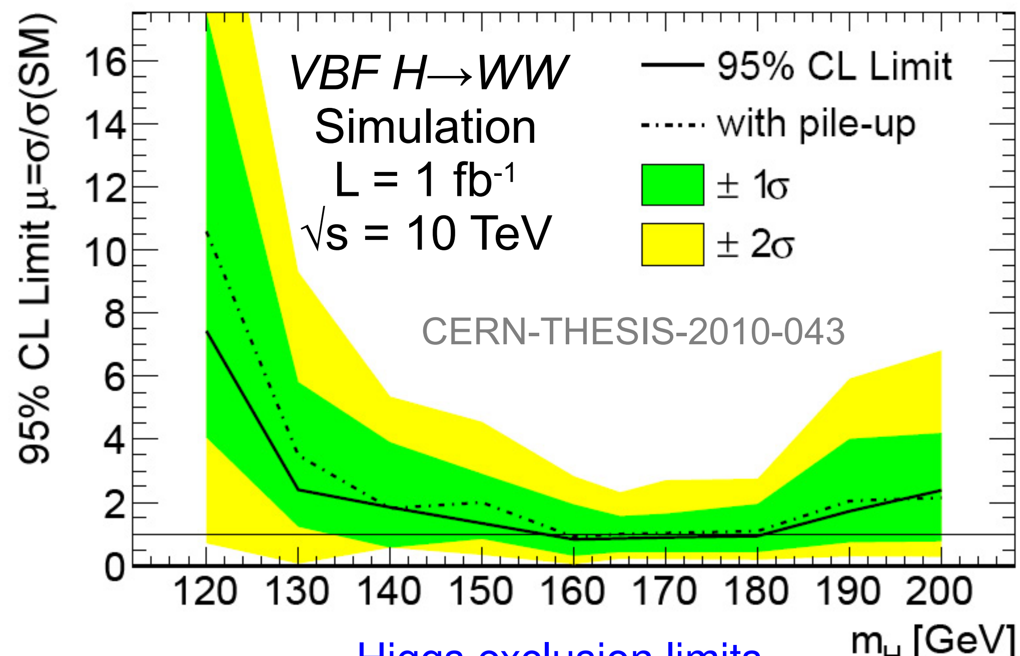
- VBF cross section production O(10) lower than via gluon-gluon fusion
  - however the topology allows efficient suppression of background
- H→WW exhibit dominant branching fraction for m(H)>160 GeV
  - main focus for 2010/2011 data
- Only W→eν, W→μν are accounted
  - W in all hadronic final state suffers from multi-jet background



Requirements to suppress background

- Two forward jets, veto on central jets
- Removal of jets having pile-up origin (method of track-based jets developed at MPP)





Higgs exclusion limits

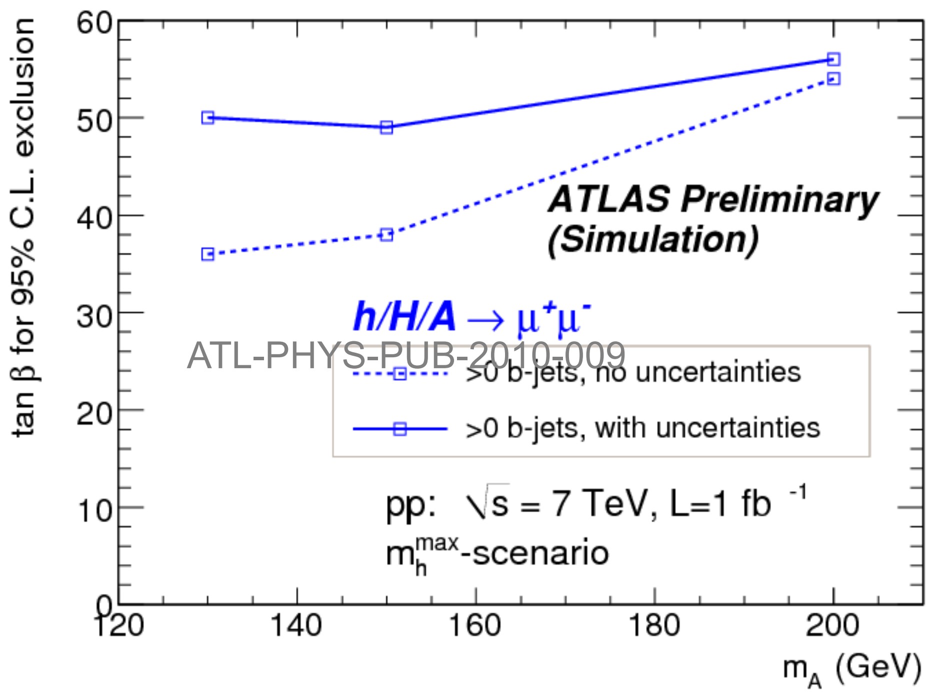
MPP is a driving force for the MSSM Higgs search in the di-muon channel

Diploma thesis and ongoing PhD work: *Sebastian Stern*

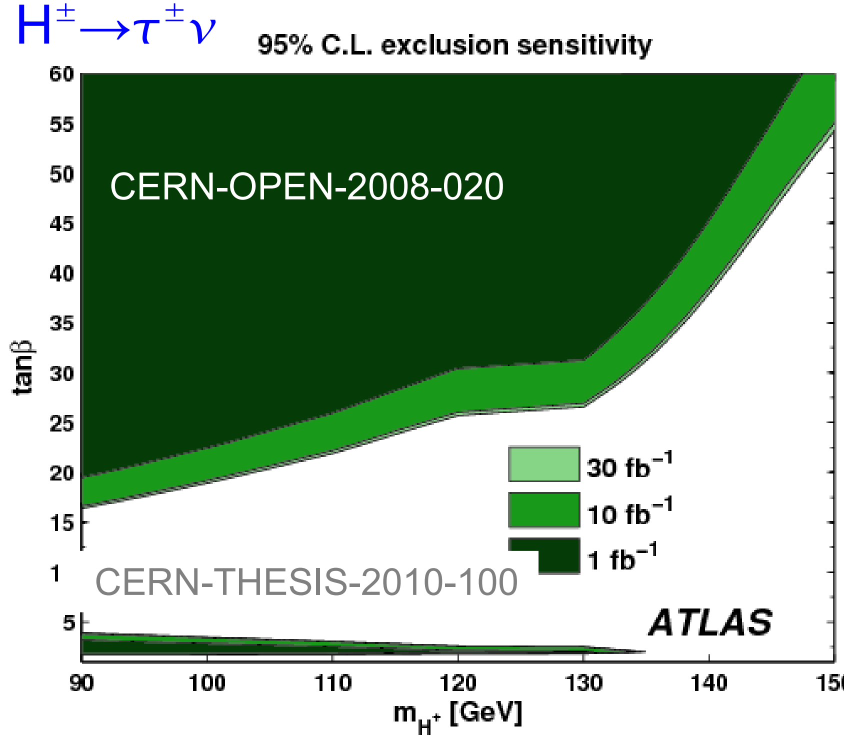
Bachelor thesis: *Sara Neuhaus, Florian Pils.*

PhD thesis: *Thies Ehrich*

$A \to \mu^+\mu^-$



$H^\pm \to \tau^\pm \nu$

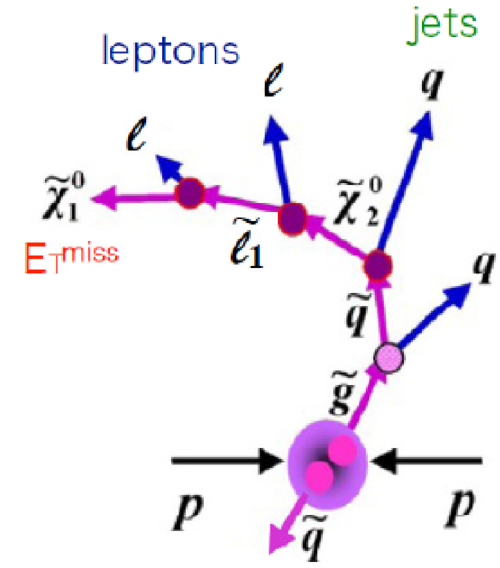


Analysis optimization and data-driven background estimation

- Recently updated for $\sqrt{s}$=7 TeV, based on the latest Monte-Carlo simulation, ongoing studies with LHC data
- Exclusion limits under preparation for the Summer Conferences 2011

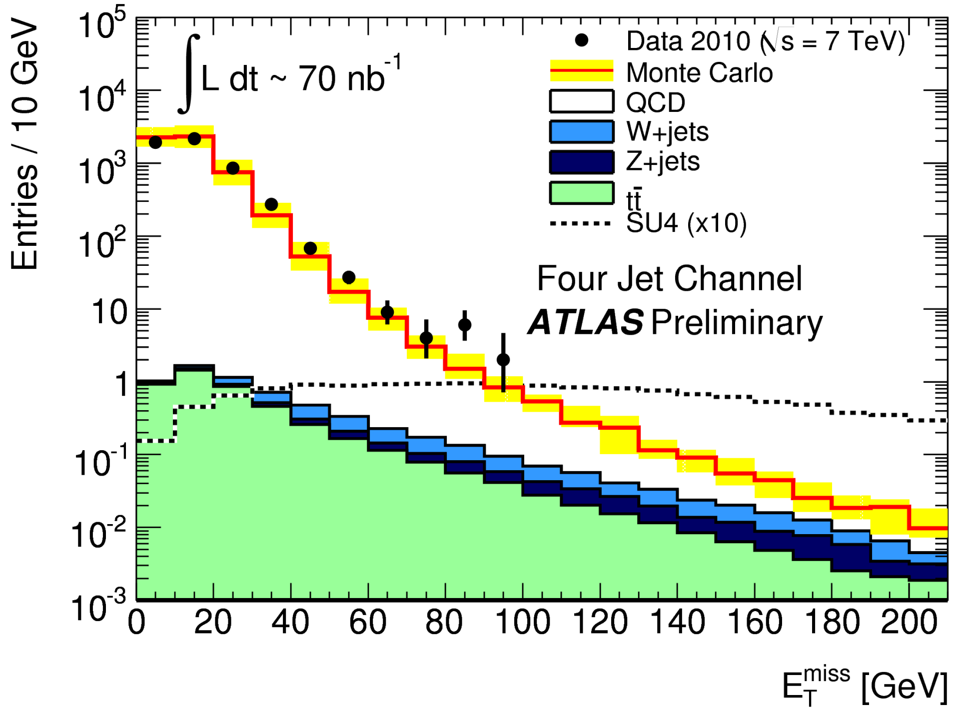
SUSY Searches

- If mass scale of SUSY particles is accessible at the LHC...
- First LHC data: search for events with multi-jets and large missing E_T due to escaping lightest SUSY particles χ_1^0
- So far the Standard Model predictions match the data well

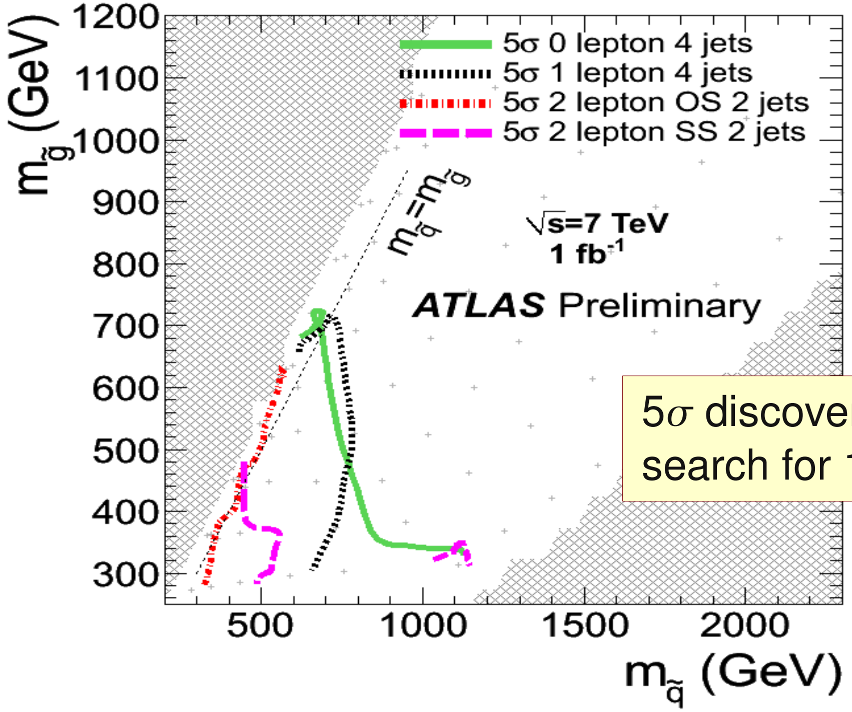


ATLAS-CONF-2010-065

$E_T$miss in >=4 jet channel



ATLAS-PHYS-PUB-2010-010

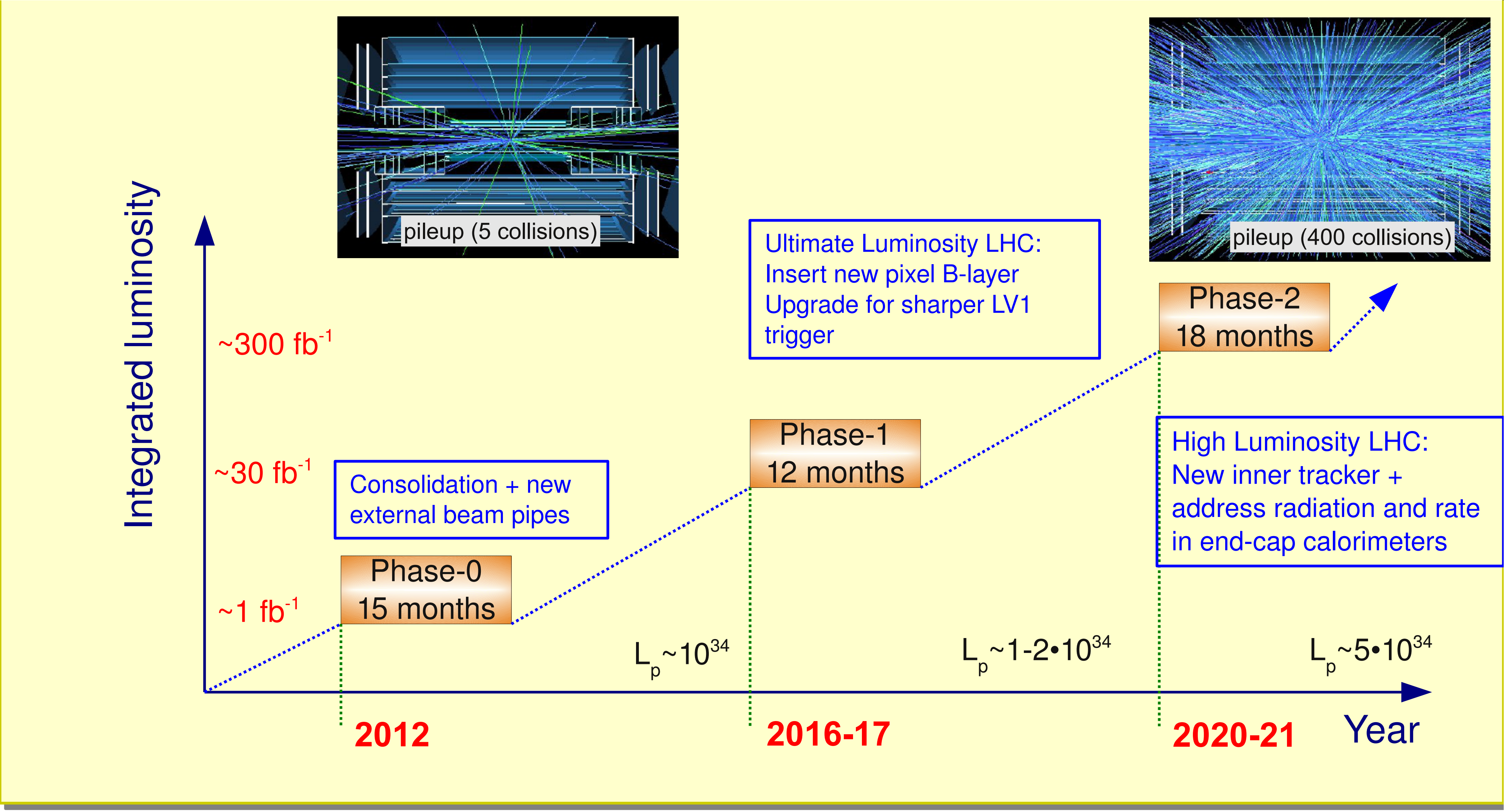


5σ discovery search for 1 fb^{-1}

- With 7 TeV data collected in 2010 part of SUSY parameter space can be excluded
  - with 1 fb^{-1} squarks and gluinos with masses up to ~700 GeV can be discovered
  - estimation of SM background from data is ongoing

- Introduction
- The Machine and the Detector in 2010
- MPP in ATLAS
  - Alignment and calibration
  - LHC data analysis
  - R&D projects for LHC upgrade
- LHC and ATLAS plans for 2011
- Conclusion

LHC and ATLAS upgrade program



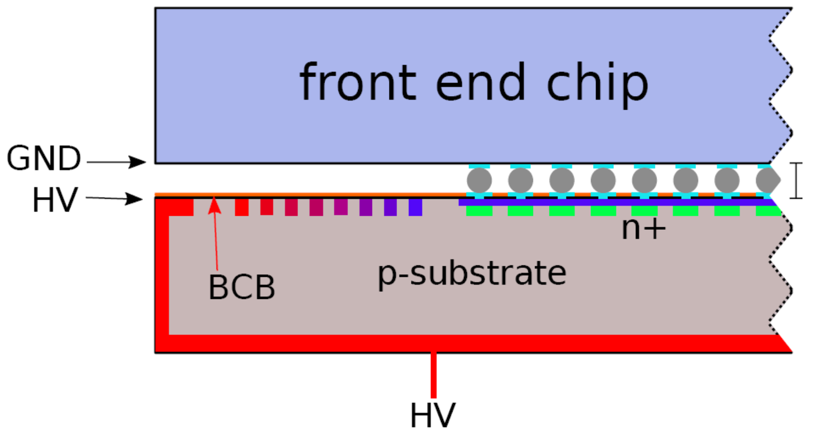
MPP at Phase-1
- ➔ Silicon pixel detector
- ➔ Forward muon detectors and trigger

MPP at Phase-2
- ➔ Silicon pixel detectors
- ➔ Liquid argon end-cap calorimeter readout electronics
- ➔ Muon trigger and readout electronics

Silicon Pixel Detector upgrade

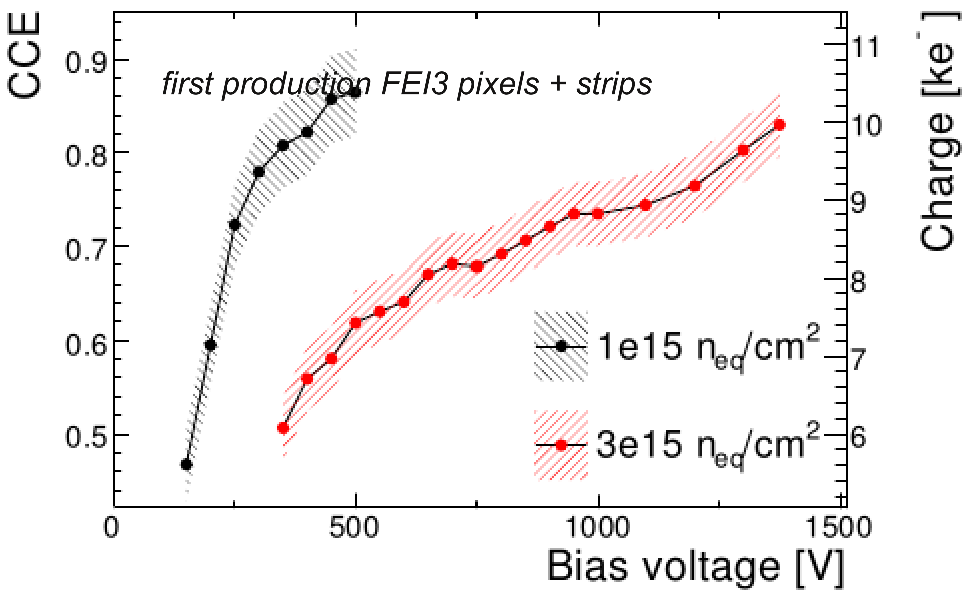
Insertable B-layer upgrade project to improve b-tagging performance and resolution (2016, Φ=5•10^{15} n_{eq}/cm^2)

Complete replacement of silicon part of the Inner Detector for HL-LHC (2020, Φ=10^{16} n_{eq}/cm^2)

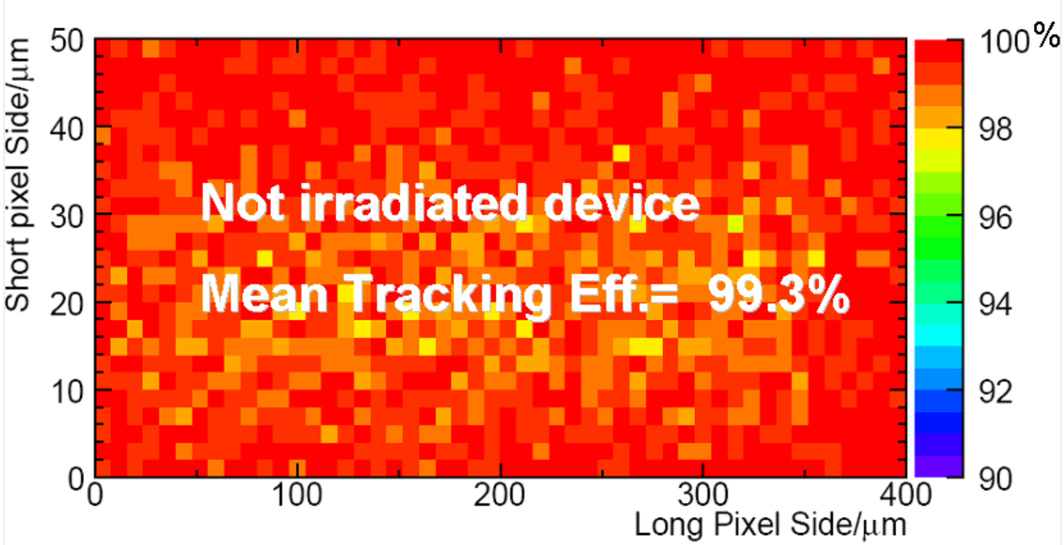


New n-in-p thin pixel sensors have been produced

- Reduced material budget (300μm $\longrightarrow$ 150μm, 75μm options)
- Thinning technology by MPP/HLL
- Less expensive due to n-in-p "single side" process



- Second production of 150 μm n-in-p pixel sensors designed for new ATLAS pixel chip FE-14 for IBL qualification (decision in 2011) is ongoing.

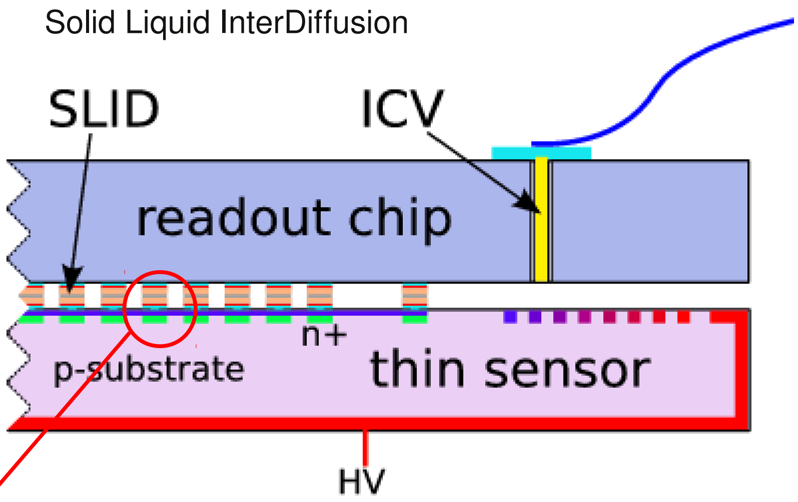


Test of tracking efficiency of first MPP fully functional 300μm thick prototype with pion beam.

Silicon Pixel Detector upgrade

Insertable B-layer upgrade project to improve b-tagging performance and resolution (2016, $\Phi=5 \cdot 10^{15}\ n_{eq}/cm^2$)

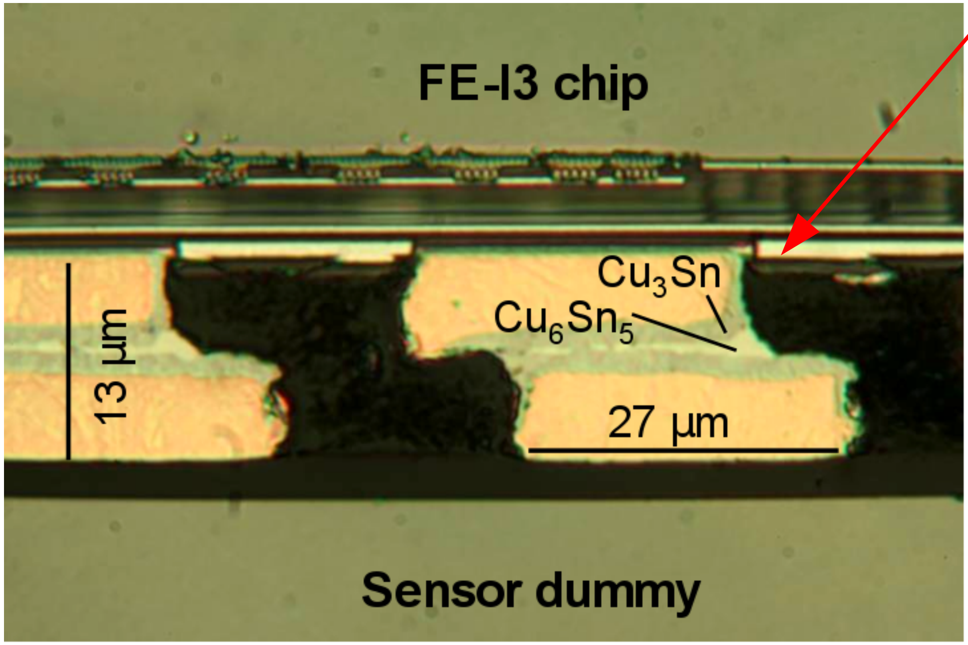
Complete replacement of silicon part of the Inner Detector for HL-LHC (2020, $\Phi=10^{16}\ n_{eq}/cm^2$)



Project for vertical integration of pixel sensors targeted for HL-LHC

- Test of SLID, new interconnection technique, with Fraunhofer EMFT
- More robust and possibly cheaper alternative to bump-bonding

In collaboration with Fraunhofer EMFT



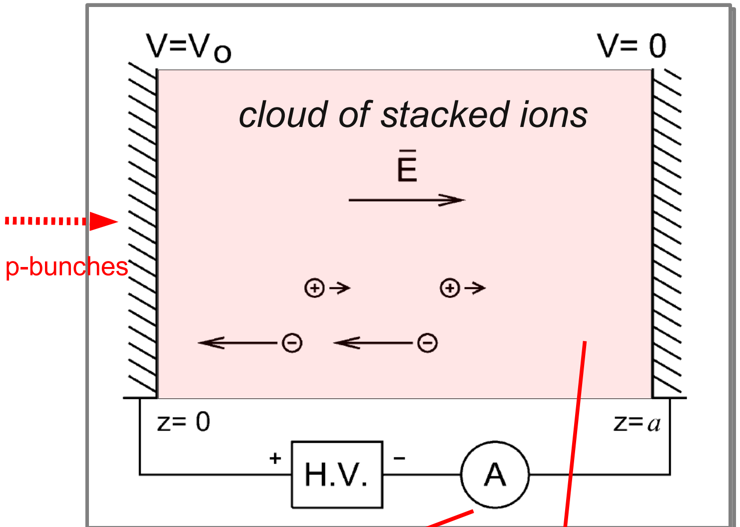
Properties of SLID interconnection studied:

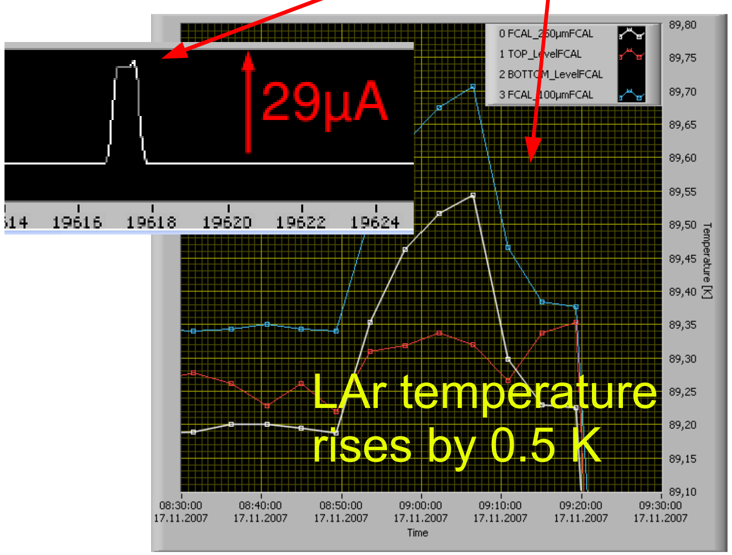
- Inefficiencies $< 10^{-3}$
- Positioning precision of order $10\mu m$

Working on interconnection between MPP thin pixel sensors and ATLAS FE-I3 chip

Hadronic Calorimeter upgrade

- HiLum ATLAS end-cap project establishes operation conditions of 3 calorimeters (EMEC, HEC, FCAL) under high radiation level

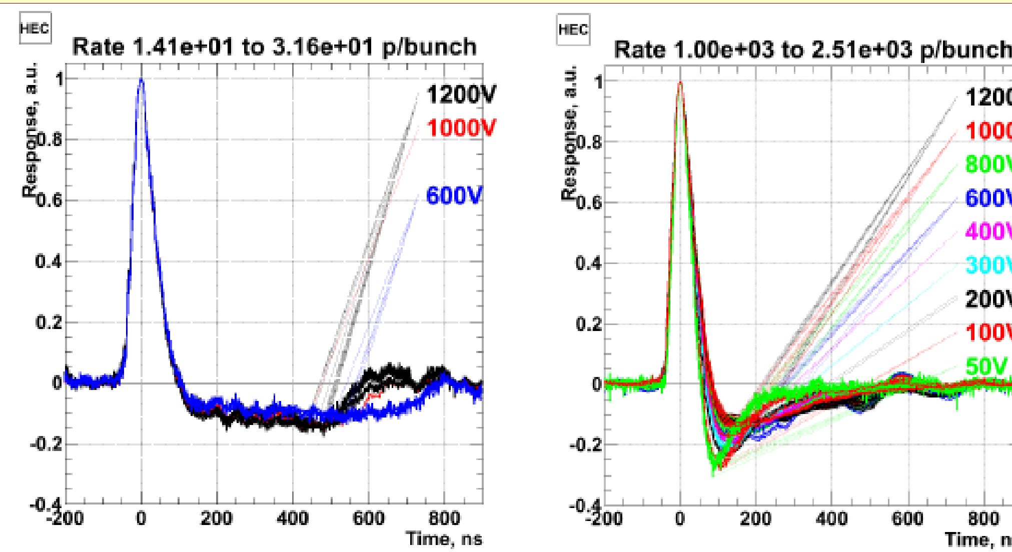




- Critical issue is ion build-up in LAr gaps: decreased electric field, increased recombination rate, distorted signal shape

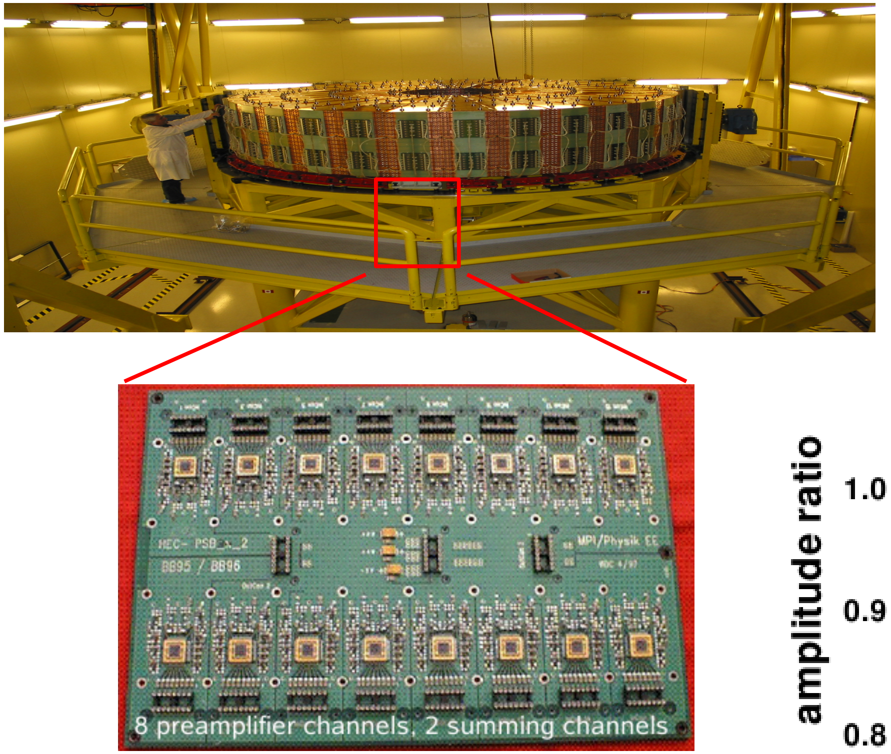
- Calorimeter modules have been exposed to the 50 GeV proton beam at the IHEP synchrotron in Protvino, Russia
  - at various intensities (10^7 - 10^{13}) protons/spill

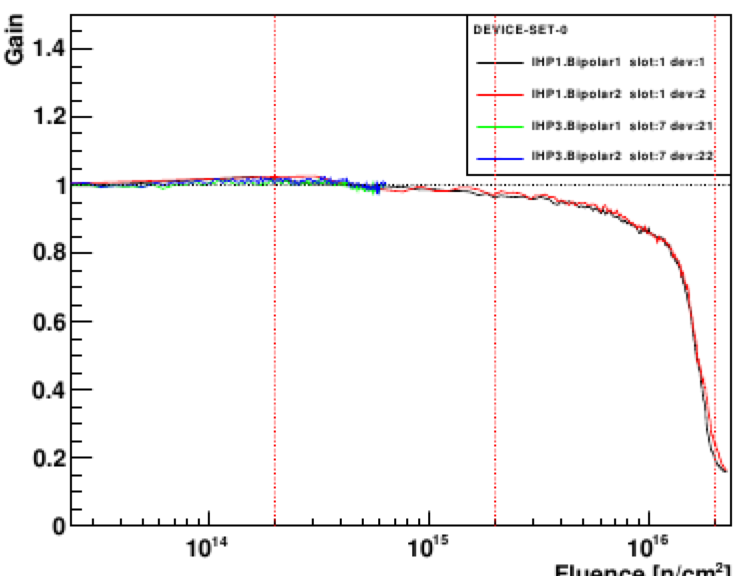
Expected signal degradation has been observed -HEC can be operated at HL-LHC, FCAL should be redesigned.



measured signal at HEC at different proton/bunch intensities

Hadronic Calorimeter upgrade

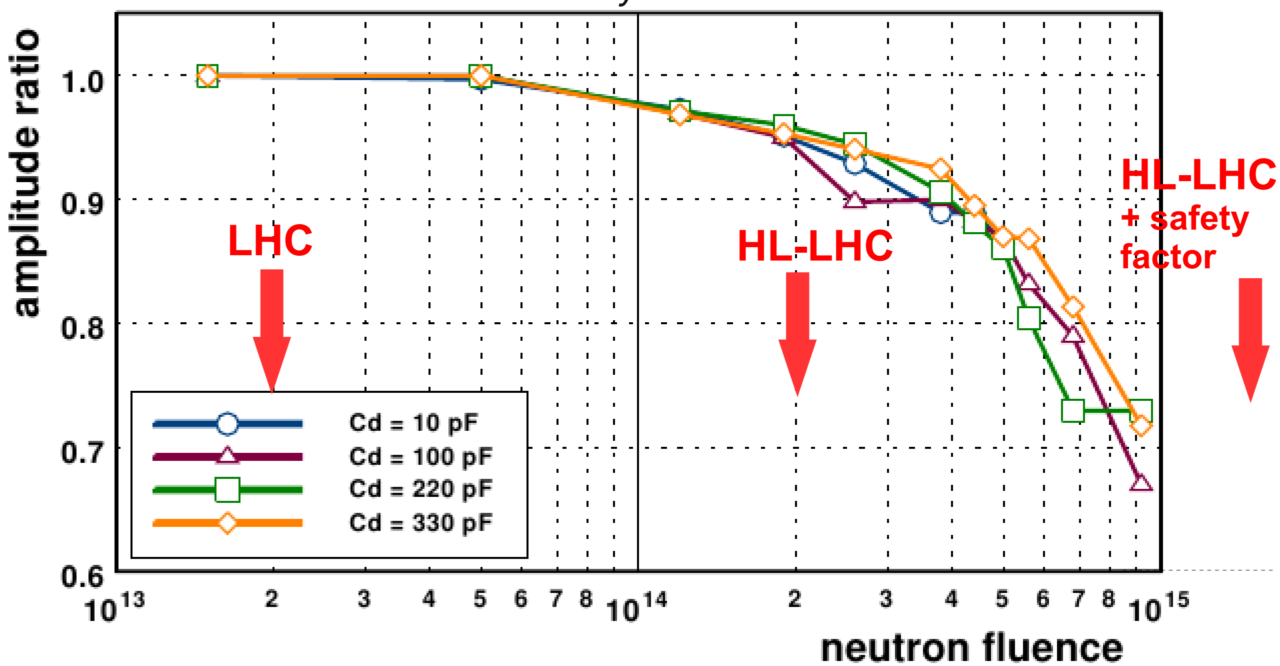




Electronics of HEC modules are operating in liquid argon.

- Radiation tolerance corresponding to 10 years of LHC with additional safety factor of 10.
- For super LHC radiation hardness is at the limit

Radiation hardness of currently installed HEC electronics

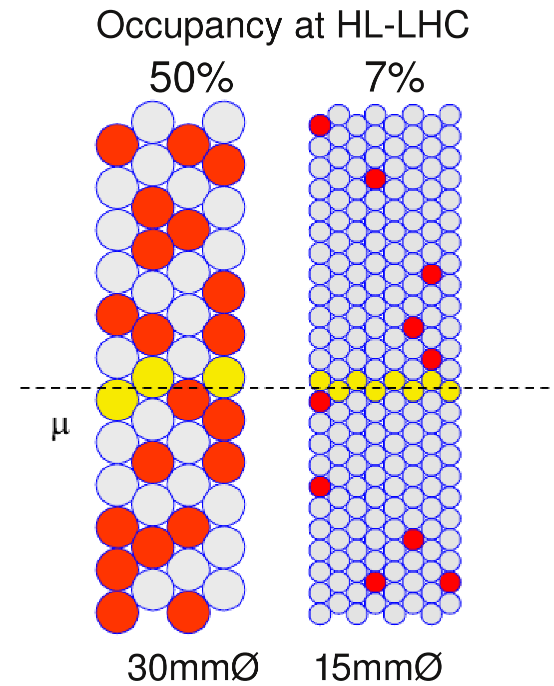


R&D for possible electronic upgrade is ongoing

- Three promising transistor technologies (SiGe, GaAs SiCMOS) have been irradiated under neutron beam in Prague.
- Si based CMOS option is currently preferred, design of whole chip is in progress.

Muon Spectrometer upgrade

- Current MDT chambers with 30 mm Ø drift tubes designed for maximum irradiation and counting rates 300 kHz/tube ($10^{34}cm^{-2}s^{-1}$)
  O(10%) occupancy due to neutron/γ radiation in the cavern → 50% at HL-LHC
- Fast muon drift-tube detector with 15mm Ø drift tubes is developed to cope with increased irradiation rates with 7x smaller occupancy



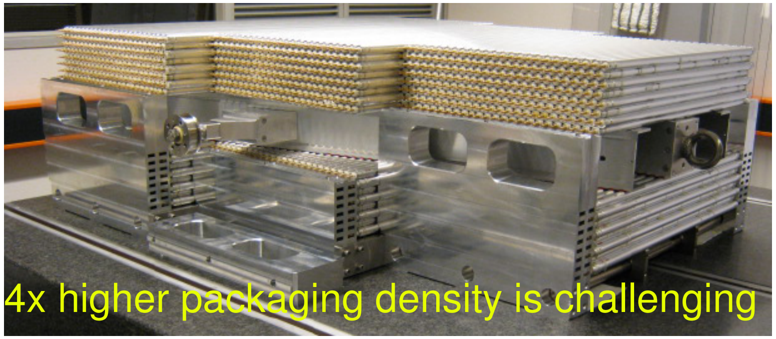
Design is ready for construction of chambers to fill acceptance gaps in barrel muon spectrometer in 2012 shutdown

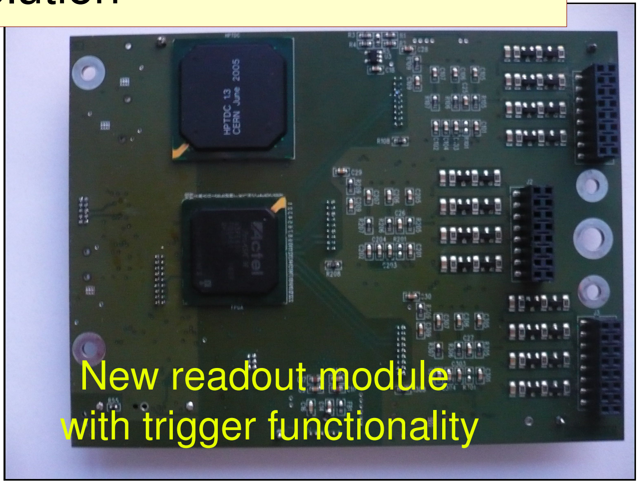
- up to 16 chambers with 7000 tubes in 2011 to be produced in house

2016/17 replacement of end-cap inner layers (small wheels)

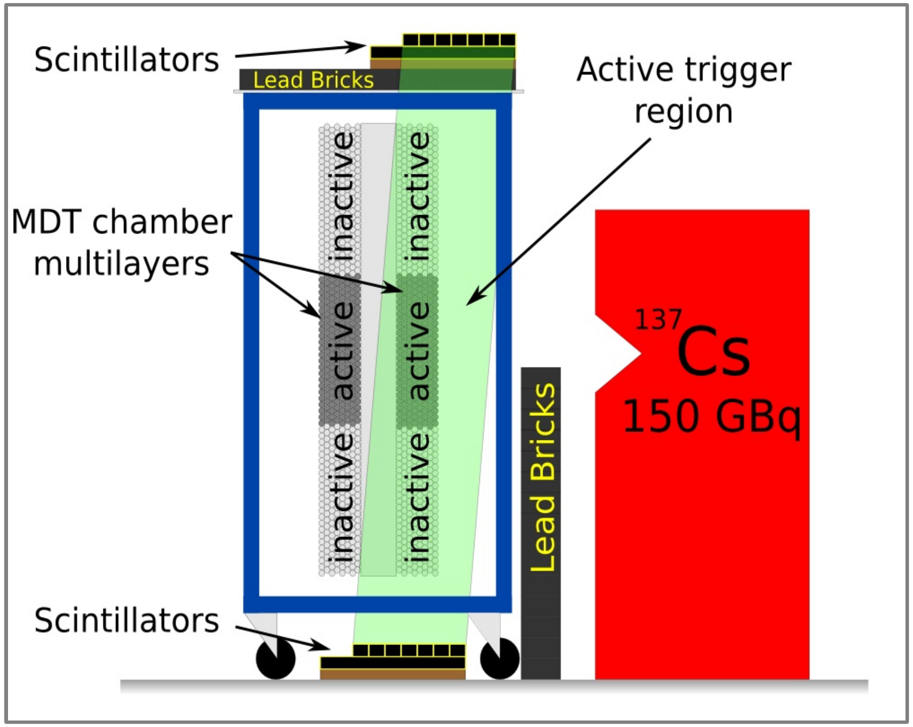
- 2x48 chambers with 35000 15mm Ø drift tubes + new electronics

2020 Integration of new radiation hard readout and trigger electronics with high momentum resolution





Muon Spectrometer upgrade

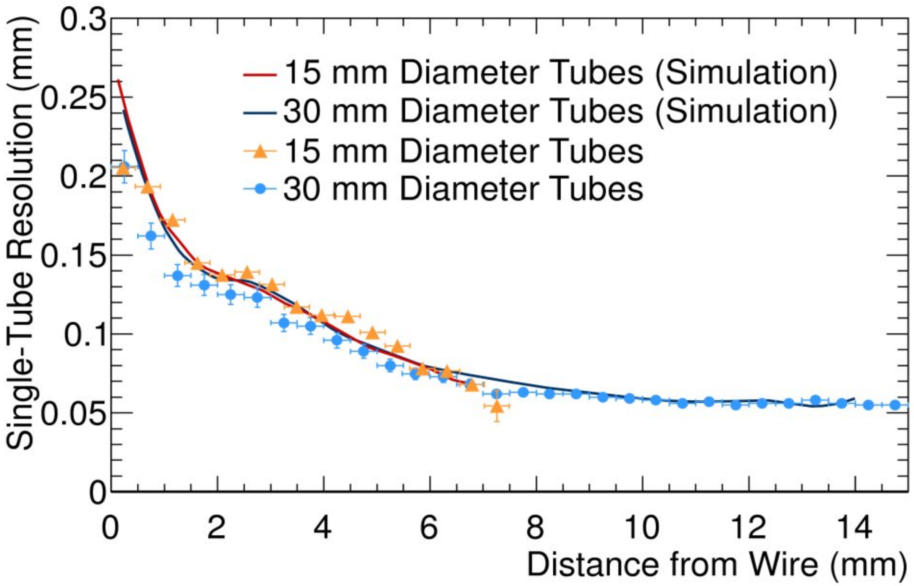


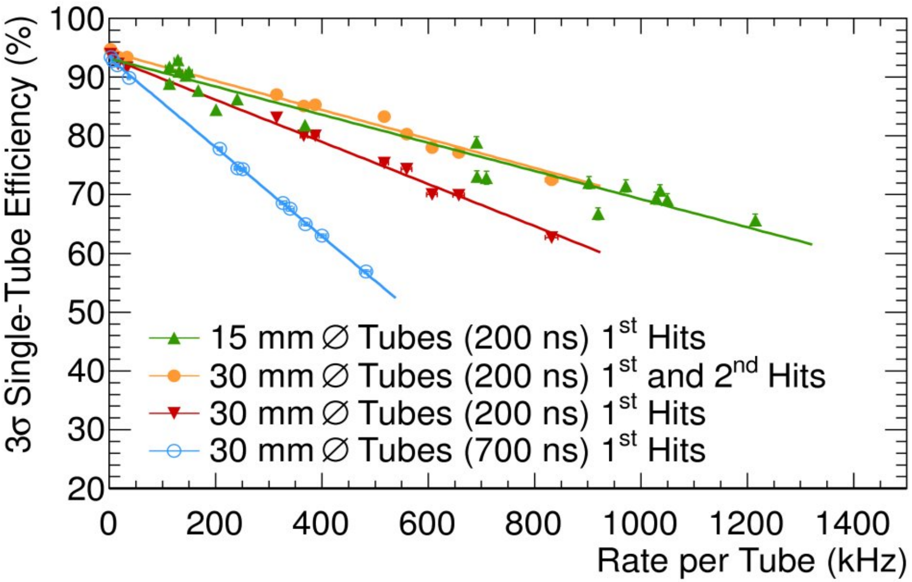
Test at CERN muon beam (H8) without background radiation

- 15mm Ø drift tube spatial resolution (bottom left) as expected from 30mm Ø tubes (and confirmed by GARFIELD simulation)

Test with cosmic muons at CERN gamma irradiation facility

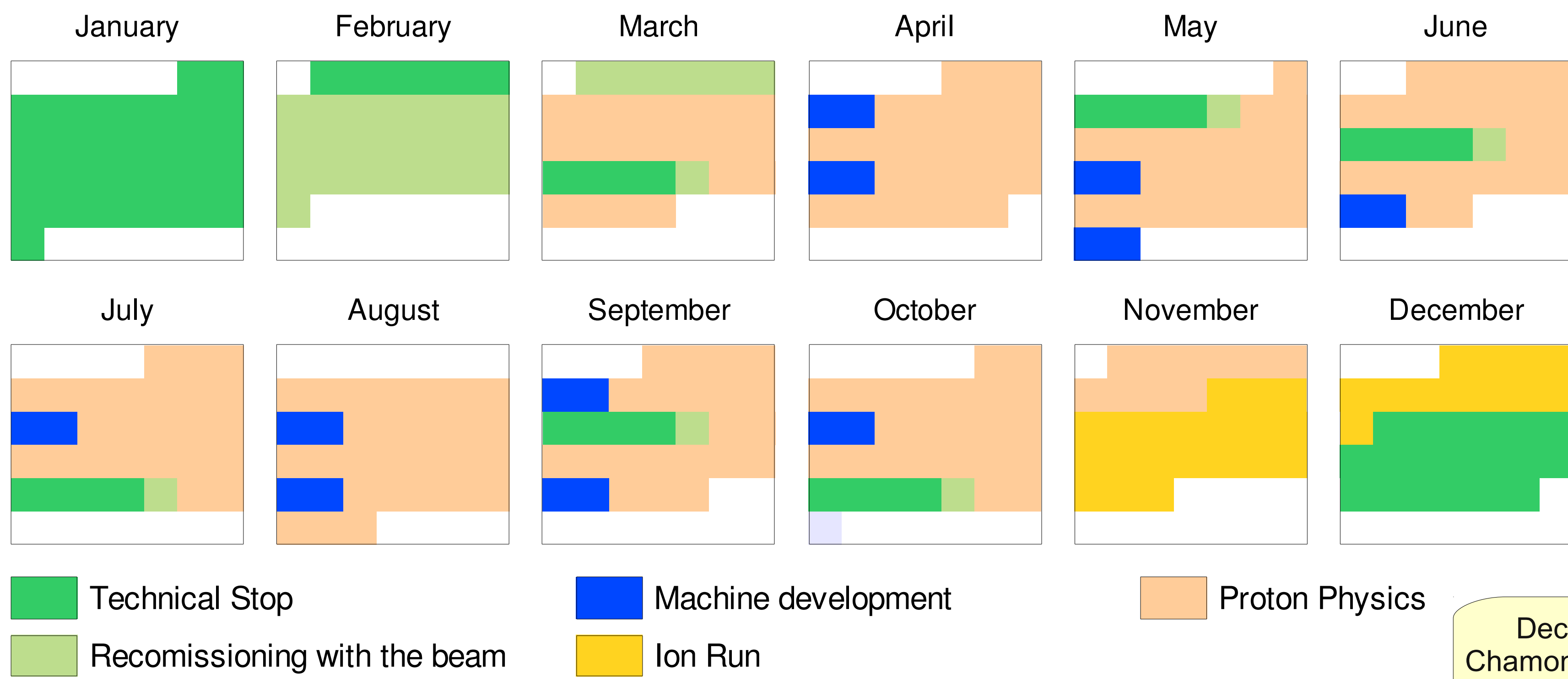
- 15mm Ø drift tube efficiency as a function of background γ counting rate (bottom right)





LHC schedule for 2011 (draft)

From Mike Lamont, LHC



Decision after Chamonix Workshop, February 2011

- Beam back around 21st February
- Machine development every 2 weeks
- 200 days proton physics
- 4 weeks ion run
- End of Run 12th December, 2011

energy	3.5 TeV (4 TeV)
bunches	936 (75 ns)
peak Luminosity	6.4×10^{32}
integrated per day	11 pb^{-1}
200 days	2.2 fb^{-1}

Conclusion

- 2010 was a great success
  - The World still exists
- Since 30th of March ATLAS has been successfully collecting data during the first LHC run at $\sqrt{s}$=7 TeV
  - detector recorded 45 pb^{-1} of LHC data with 92% efficiency
- The first data demonstrate that the detector performance is as good as expected and in agreement with detailed simulation.
- Broad range of measurements from low pt to high pt: resonances, jets, W and Z bosons, top events and search for new physics beyond the SM.
  - Many more results to come next months
- Significant amount of data O(fb^{-1}) is expected next year
  - Start to be competitive to Tevatron for Higgs search
- Major contribution of MPP to construction, commissioning, operation, physics analysis and upgrade activity of ATLAS experiment.

Hector Berlioz, “Les Troyens”, opera in five acts.

ATLAS control room

Bonus Slides

Heavy Ions Period: indication of jet quenching

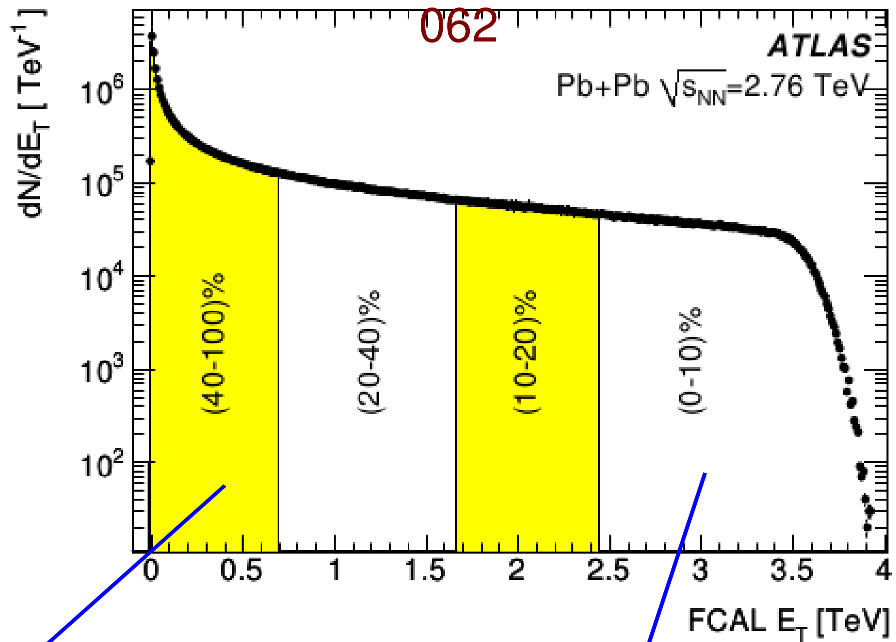
CERN-PH-EP-2010-062

November, 20 - ATLAS reported observation of centrality-dependent di-jet asymmetry!

Study is focused on the balance between highest transverse energy jet pair (E_T>100 GeV, E_T>25 GeV) in the case of small missing E_T

$$A_J = \frac{E_{T1} - E_{T2}}{E_{T1} + E_{T2}}, \phi > \frac{\pi}{2}$$

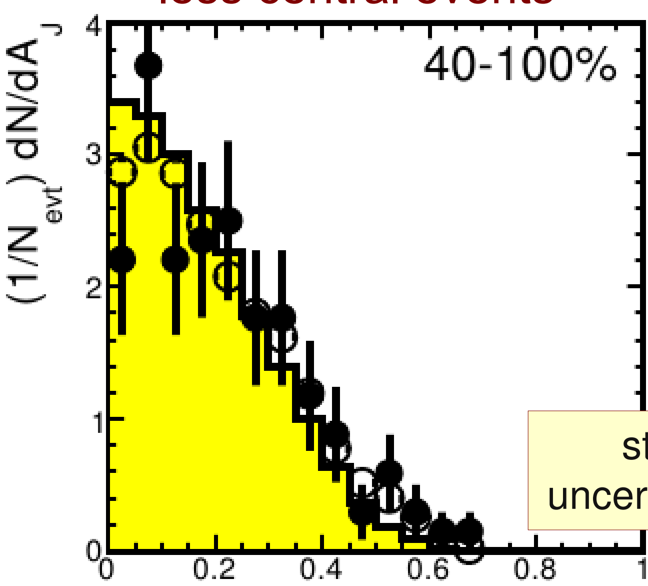
Asymmetry as a function of event "centrality" (ratio of total E_T energy deposited in the forward calorimeter)



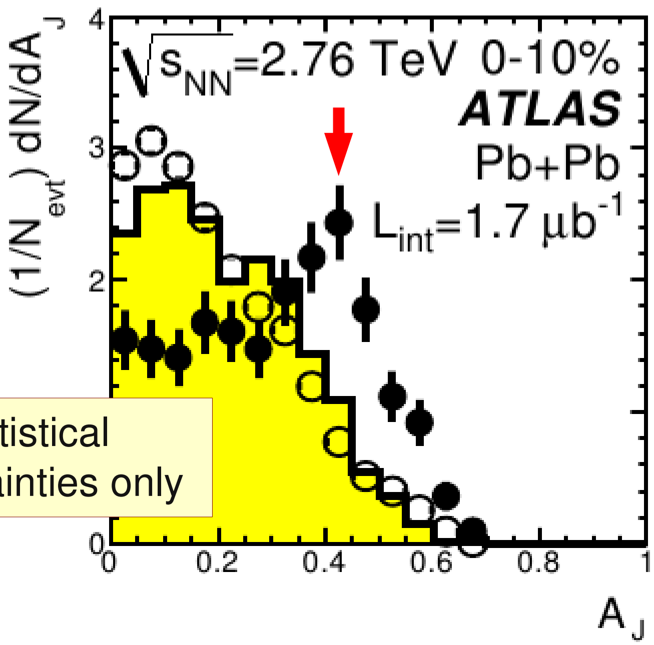
3 data sets are compared:
- ● lead-lead data
- PYTHIA + HIJING (unquenched)
- ○ proton-proton data

As events become more central, lead-lead data indicates an increased rate of highly asymmetric di-jet events

less central events



more central events



statistical uncertainties only

ATLAS at MPP

Muon Drift Tube chambers (MDT)

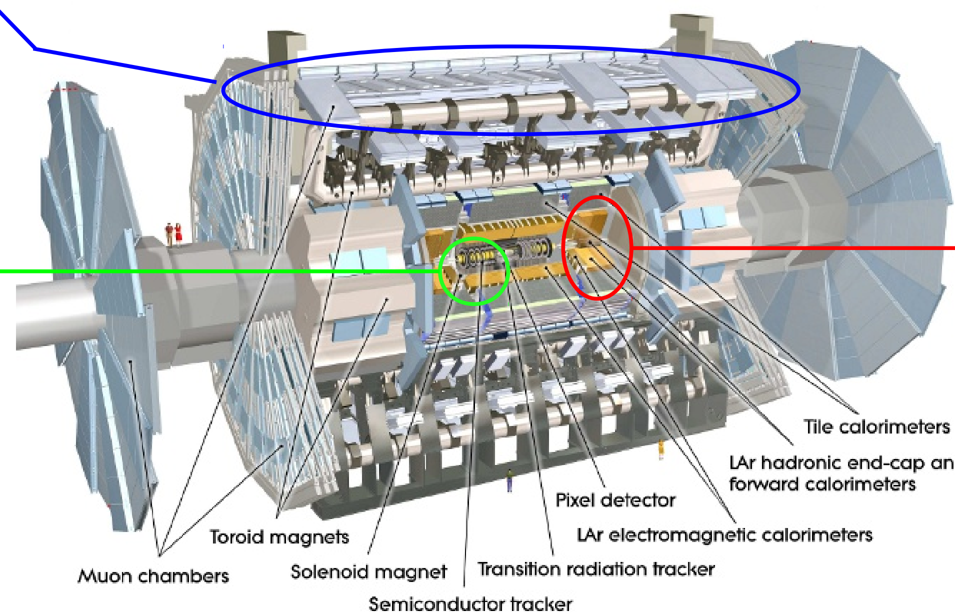
- 15% of precision drift-tube chambers
- Optical alignment monitoring system
- Muon chamber alignment and calibration

Hadron Endcap Calorimeter (HEC)

- 25% of the HEC
- Cold readout electronic
- Hadronic shower and jet calibration

Semiconductor Central Tracker (SCT)

- 10% of the silicon strip detector modules for the SCT
- Inner tracker alignment

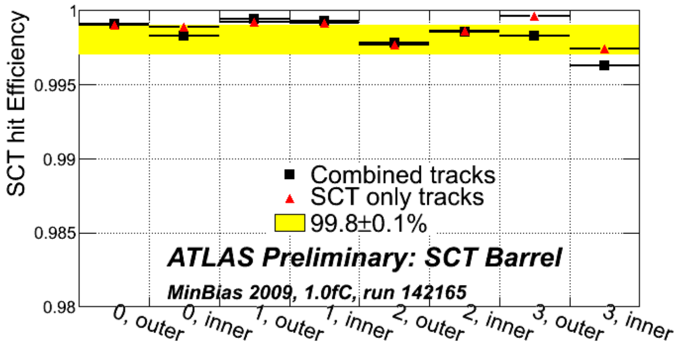


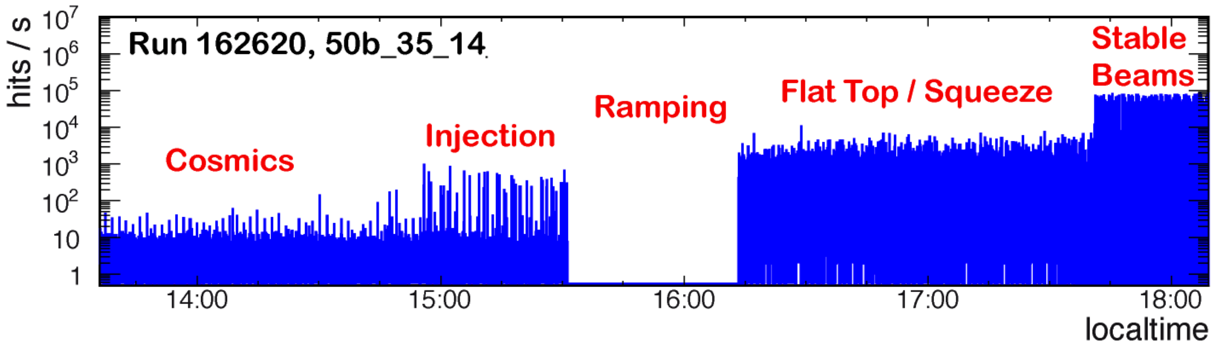
Silicon Tracker Operation & Performance

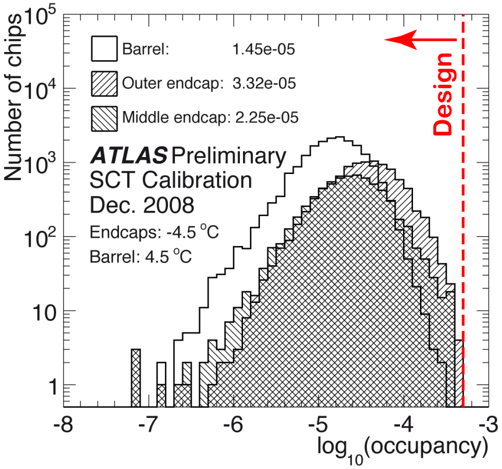
SCT is in a good shape:

- > 99% of the detector operational
- SCT geometry extremely stable
- Hit efficiency 99.8%, Design: 99%
- < 0.2% disabled noisy strips
- Full SCT very well timed in
- Excellent beam conditions monitor (only silicon tracker at LHC powered during non-stable beams)
- Known Issues:
  - Severe optical link failures (~2-3 per day)
  - Replace by spares to ensure operation
  - New production needed when cause found

disabled modules	#	%
Cooling	13	0.32
Low voltage	7	0.17
High voltage	6	0.15
Readout	13.7	0.34
Total	39.7	0.97







Hadronic Shower and Jet Calibration

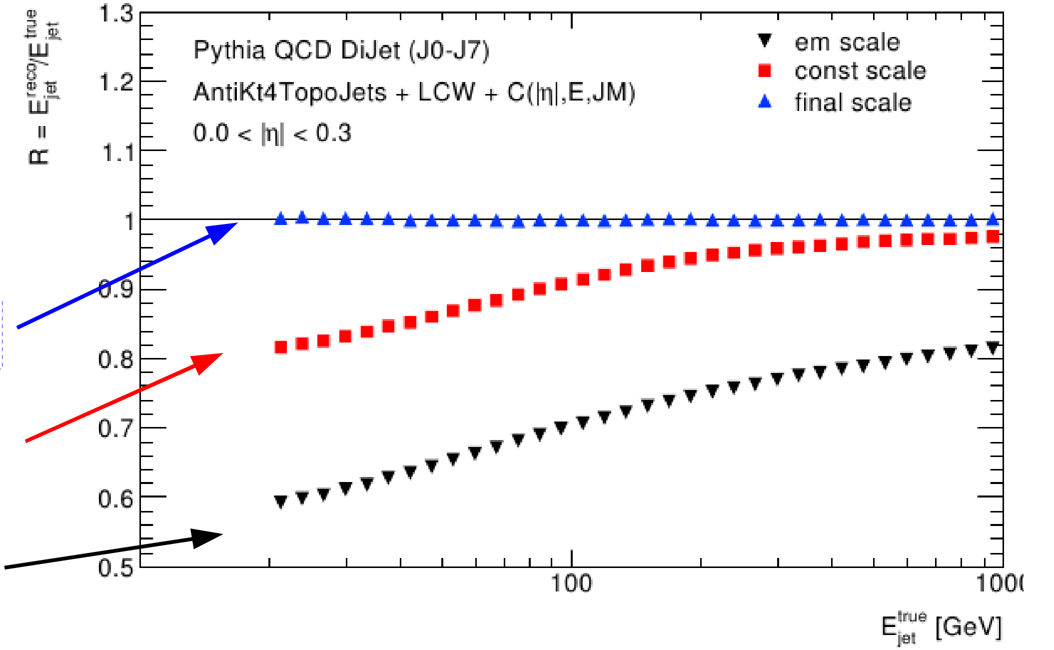
Closure tests

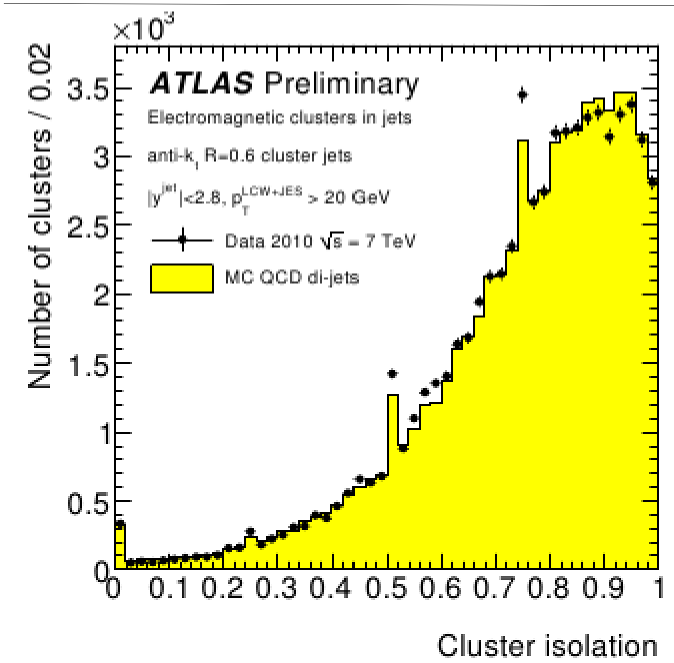
- The ratio of reconstructed jet energy to the energy of matched truth jet before and after calibration

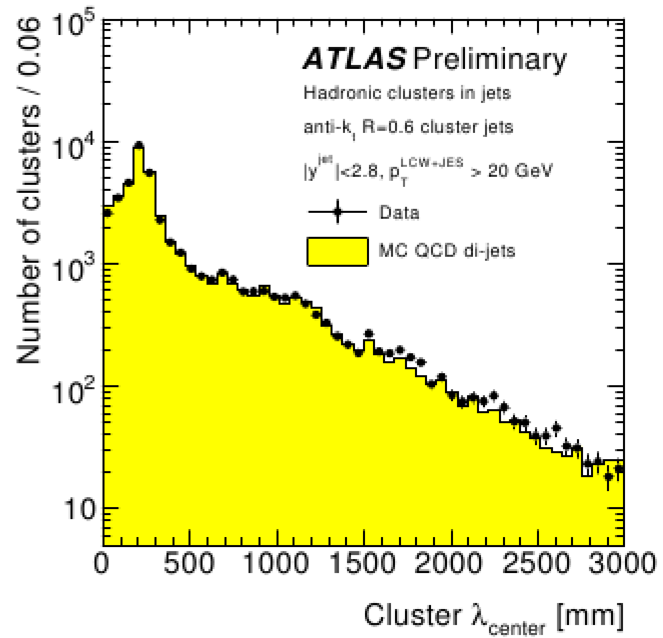
Reco jet corrected for particles lost before calorimeter

Reco jet corrected for *had* compensation, out-of-cluster and dead material losses

Reco jet at *em* scale





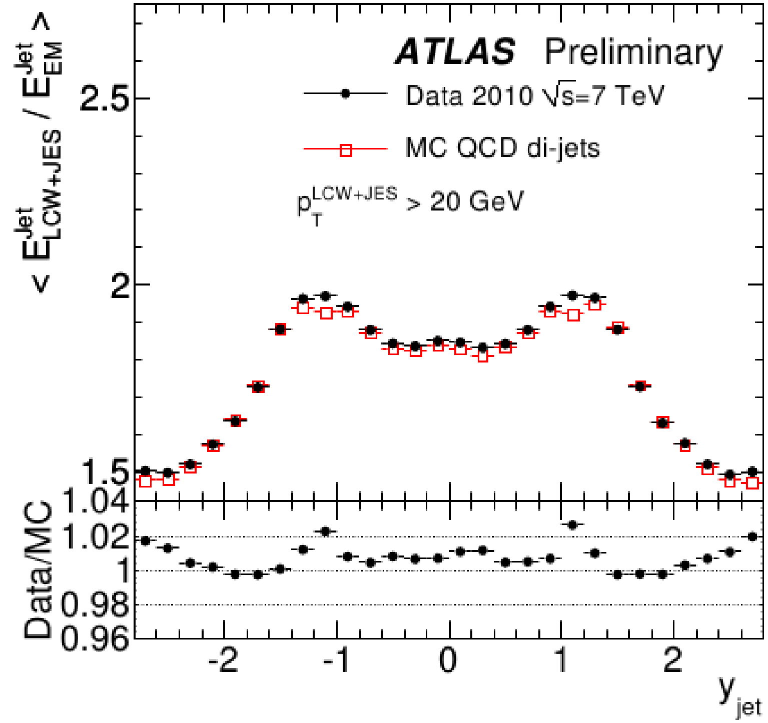


Monte Carlo validation with $\sqrt{s}$ = 7 TeV data

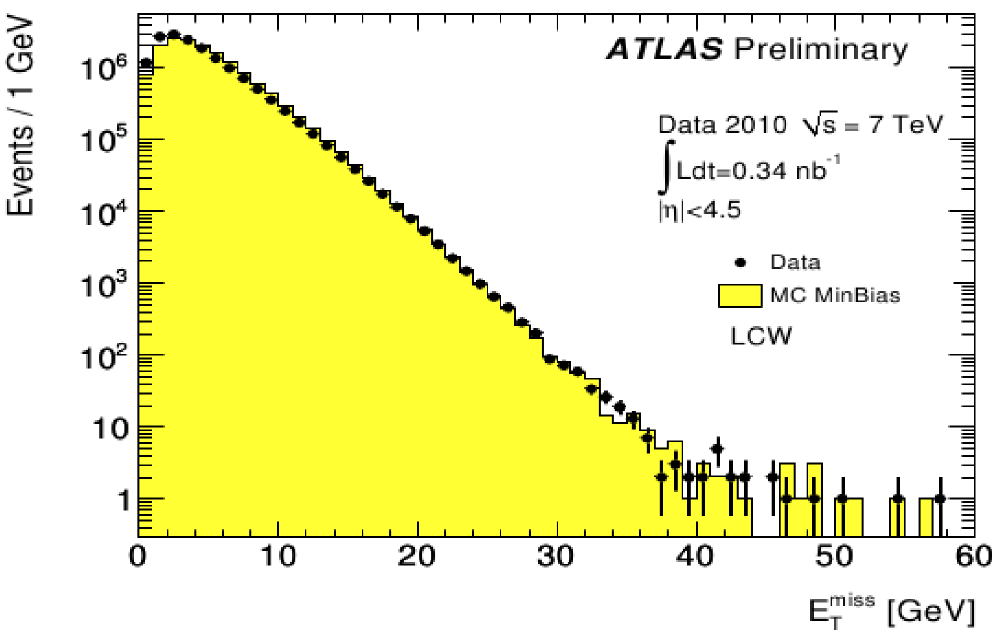
- Local Hadronic Calibration is MC based approach which implies validation with data
  - Distributions of cluster isolation moment in jet and cluster depth show excellent agreement between data and QGSP_BERT shower model

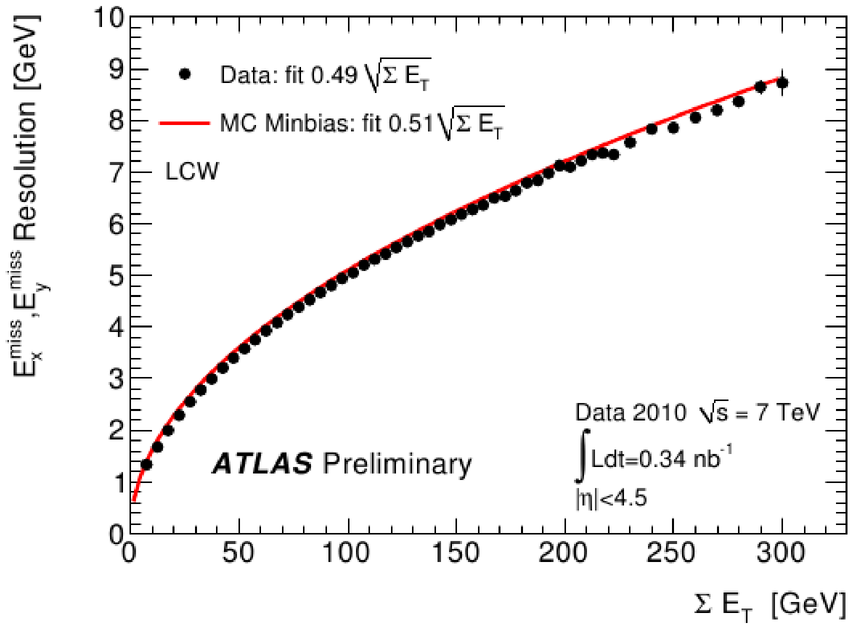
√s = 7 TeV data

- Ratio of calibrated jets over jets at *em* scale (uncalibrated) versus rapidity
  - Correction is applied both to jets in data and MC
  - Level of correction is the same



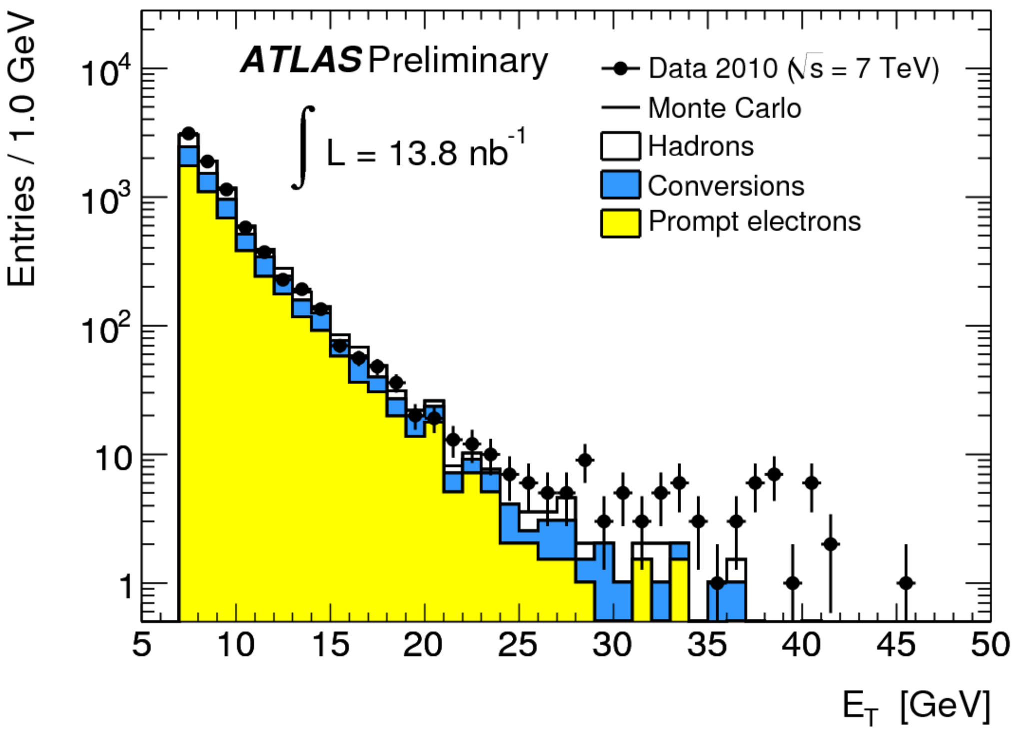
- Like for jets hadronically calibrated clusters are used for missing E_T
  - Bottom left: missing E_T distribution in √s=7 TeV data and MC
  - Bottom right: missing E_T resolution as a function of total transverse energy





Inclusive electron cross section measurements

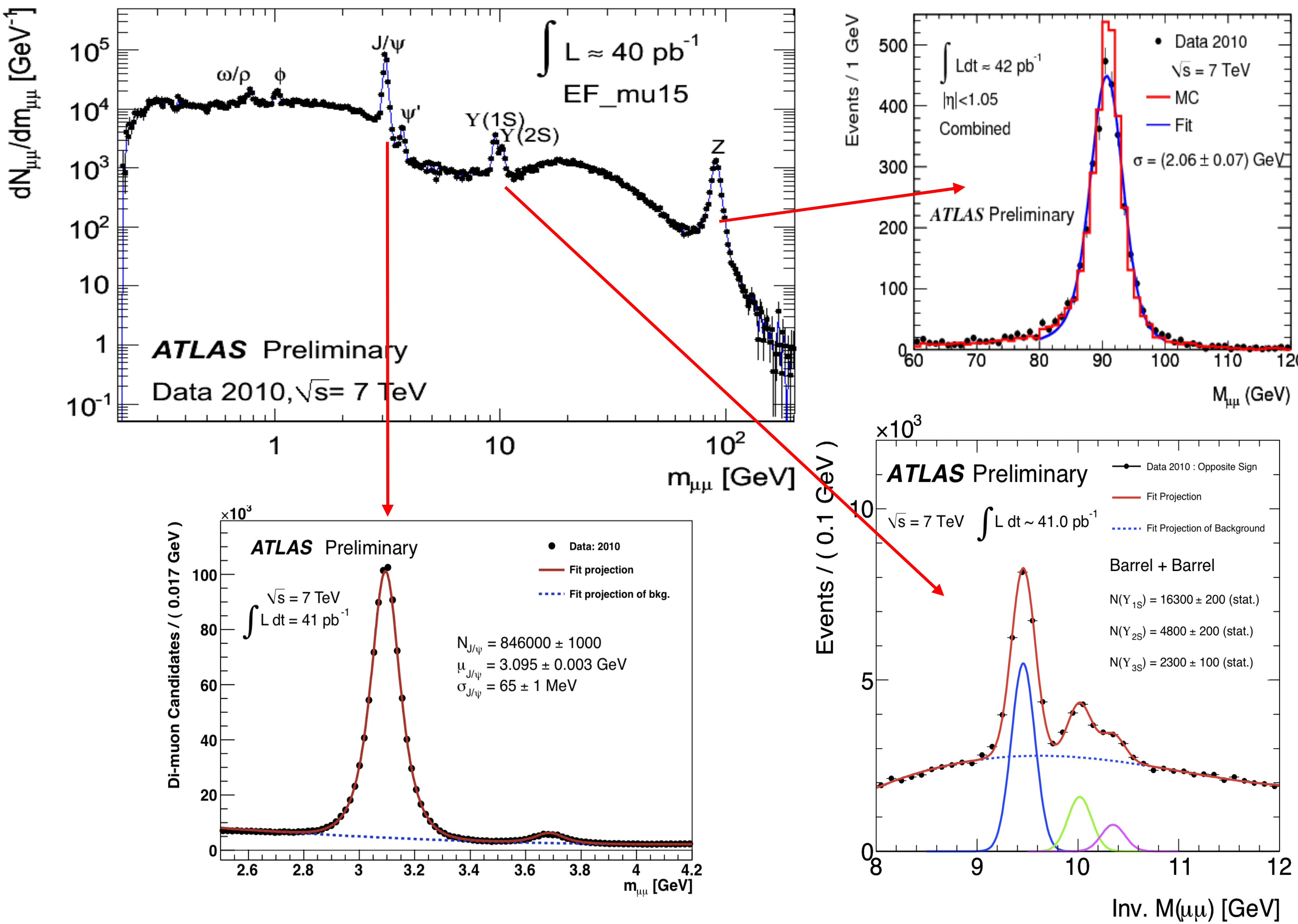
E_T distribution of electron candidates after tight selection



- Aim: to measure heavy flavor (H_b/H_c) cross sections using an inclusive electron sample
- Main tasks:
  - Extraction of signal, dominated by 9x larger background (hadron fakes and conversions)
  - Unfolding of detector efficiency and resolution
  - Further unfolding of hadronisation effects and comparison with FONLL predictions
- Method presented at ICHEP:
  - https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2010-073/

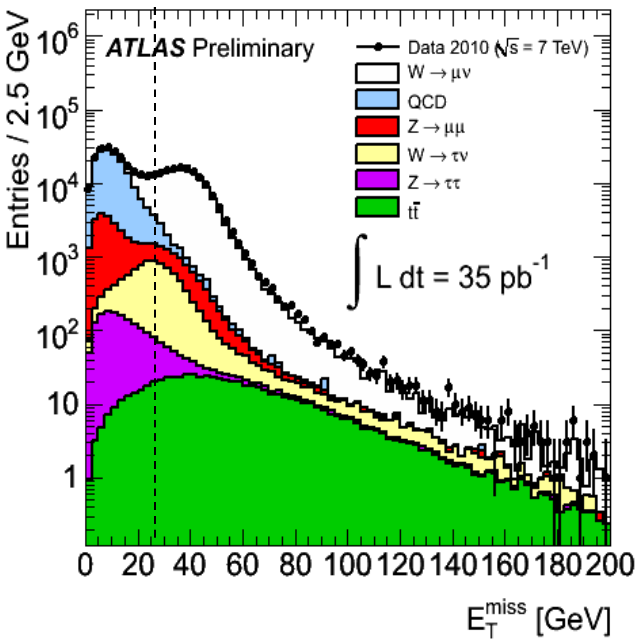
- MPP has contributed to many parts of the analysis
  - Generation of POWHEG (NLO) bb/cc samples, for systematic studies of identification and hadronisation uncertainties
  - Studies of the different signal extraction techniques (systematic biases, use of different discriminating variables, identification efficiency extraction)
  - Currently studying uncertainty of reconstruction efficiency
  - New CONF note is in preparation.

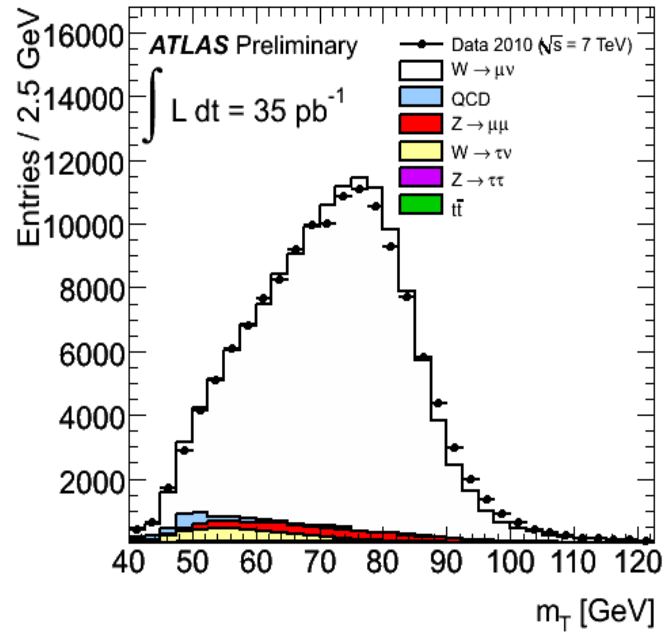
Dimuon mass spectrum and resonance peaks



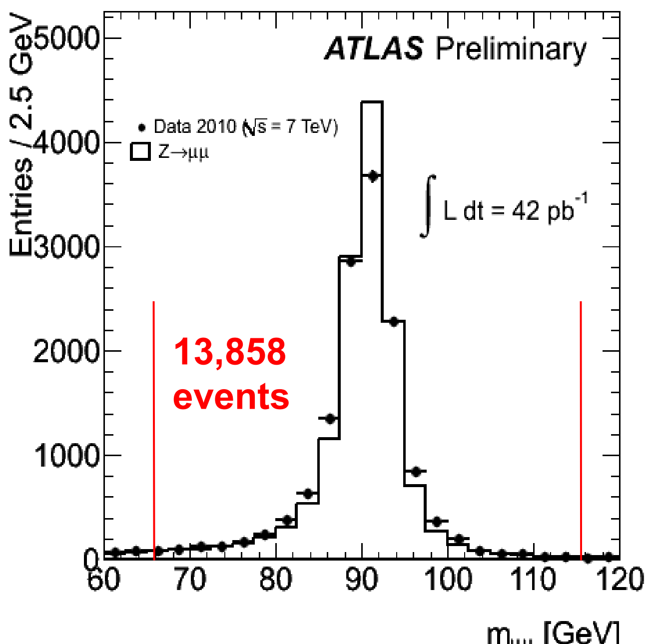
Electroweak gauge boson studies

W→μν

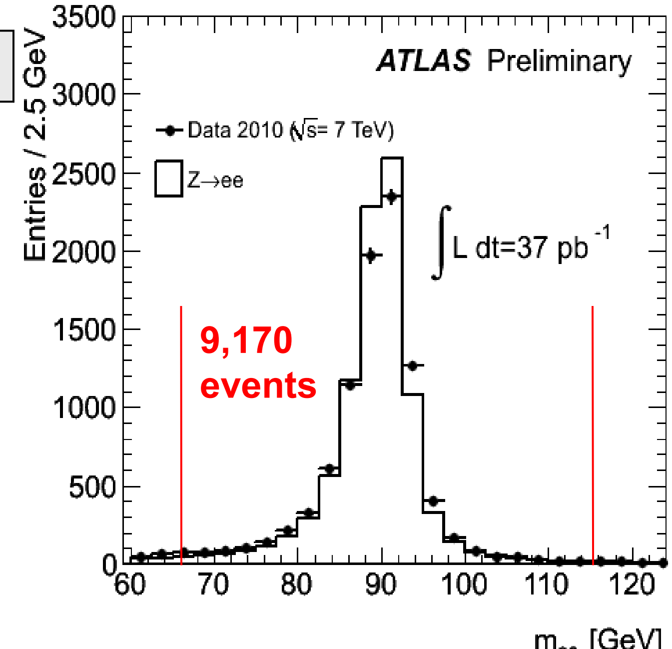




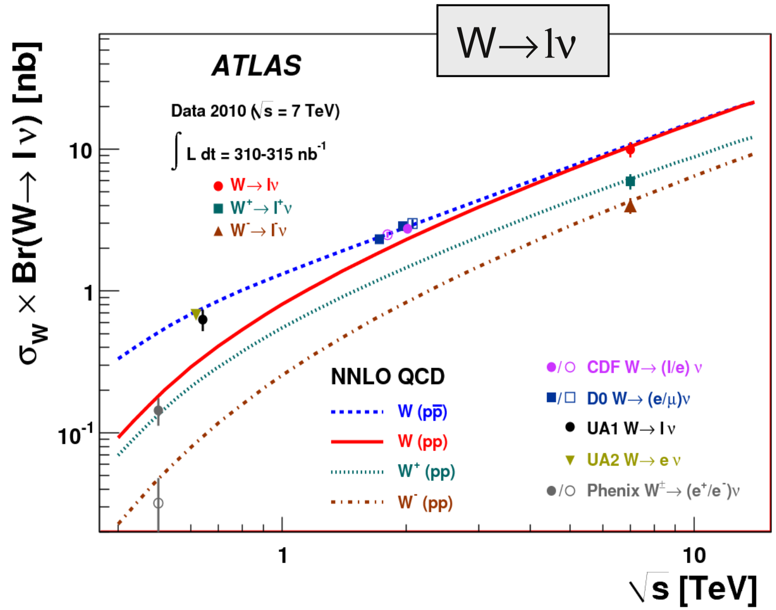
Z→μμ

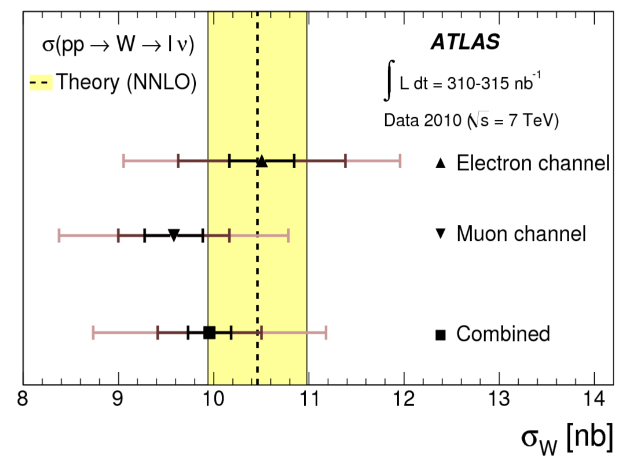


Z→ee

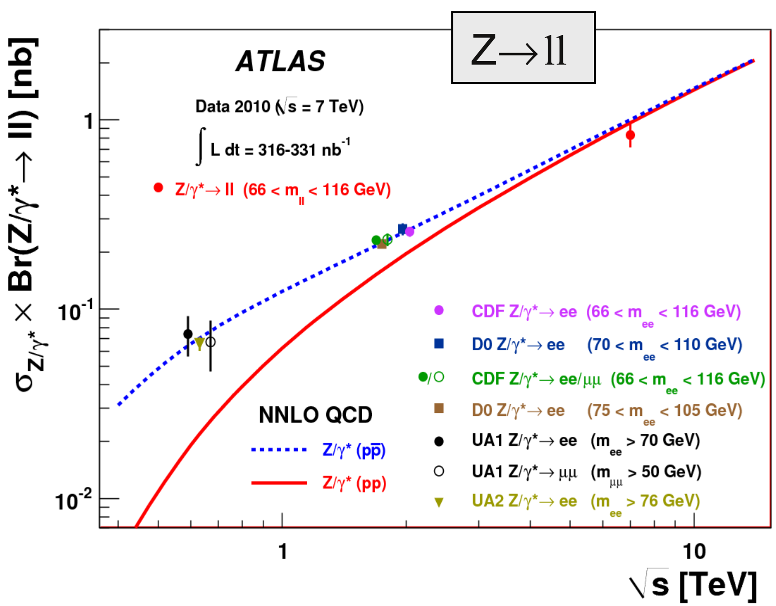


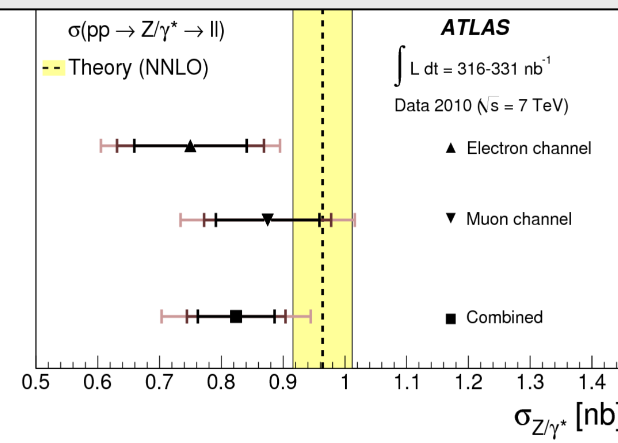
Electroweak gauge boson studies





σ_W x BR($W \to l\nu$) = 9.96 $\pm$ 0.23 $\pm$ 0.50 $\pm$ 1.10 nb





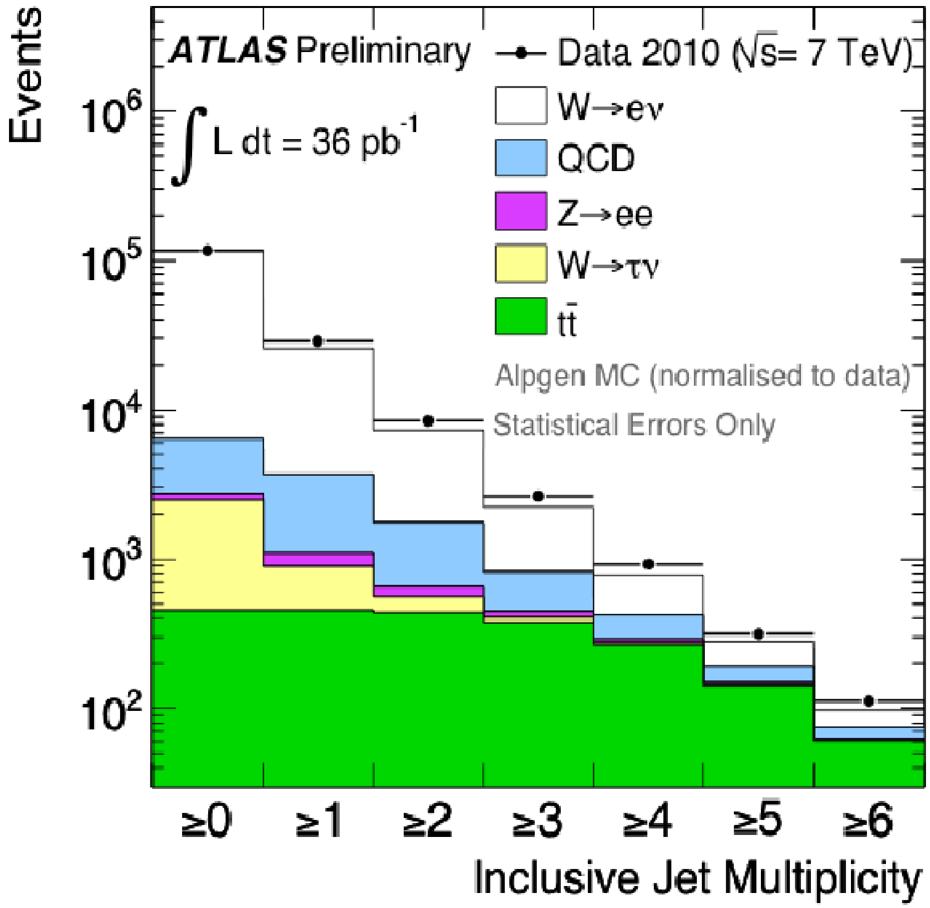
$\sigma_{\gamma/Z}$ x BR($\gamma^*/Z \to ll$) = 0.82 $\pm$ 0.06 $\pm$ 0.05 $\pm$ 0.09 nb

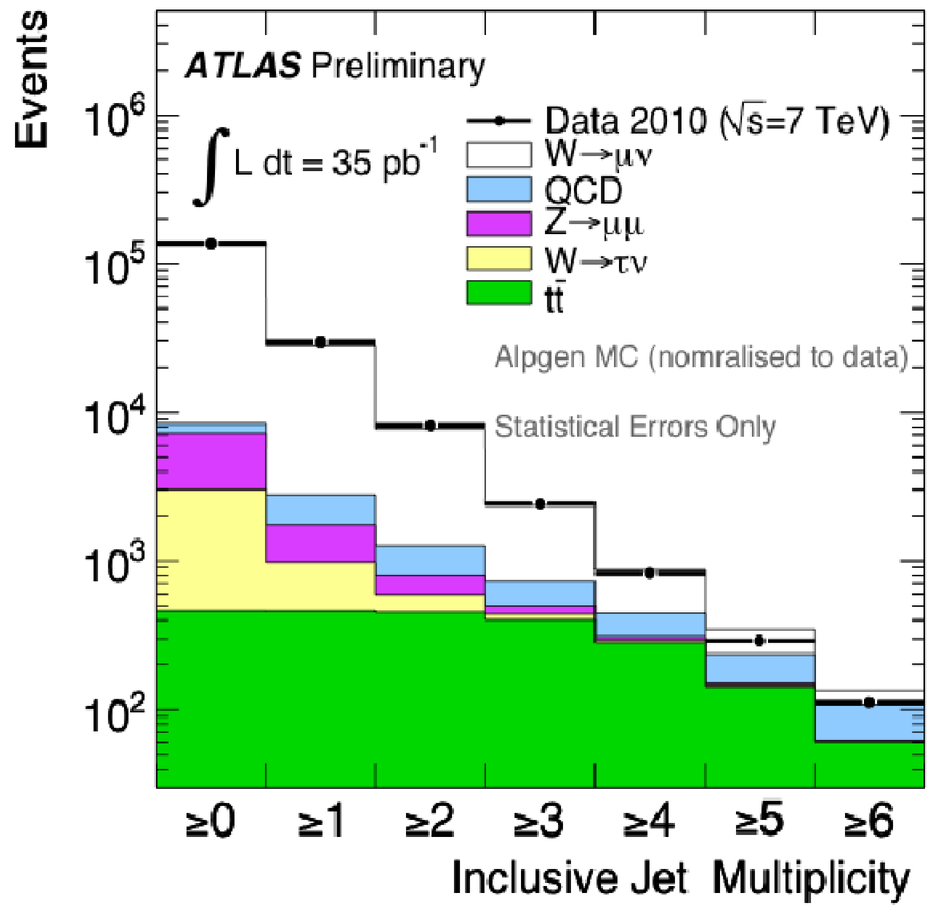
arXiv:1010.2130, subm. to JHEP

W, Z prod. cross section measurement, good agreement with SM NNLO prediction.

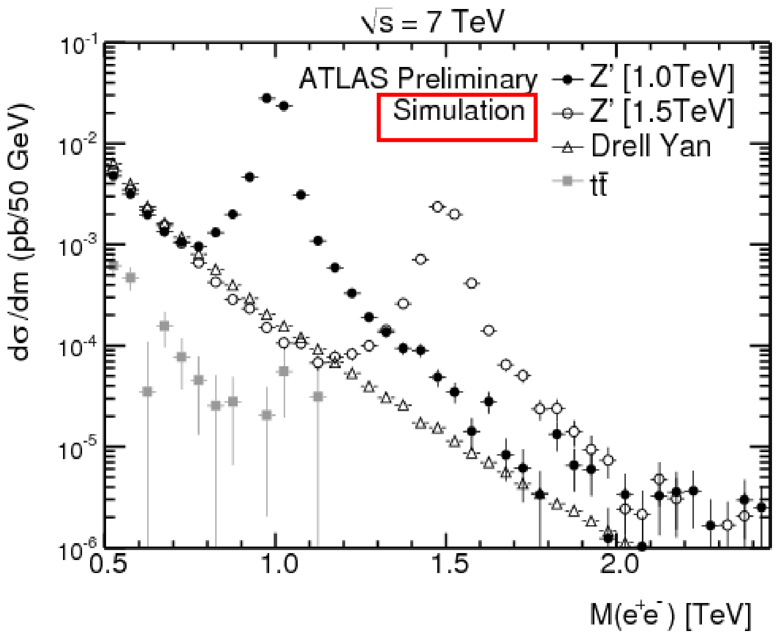
W+jets production

Distribution of the number of jets in selected W event





Search for heavy gauge bosons: *Z'*



- Background very small.
- Tevatron (CDF) mass limit 1 TeV.
- Can be improved with ≥ 30 pb^{-1}, mass limit > 1.5 TeV with 400 pb^{-1}.
- 5σ discovery potential above 80 pb^{-1}.

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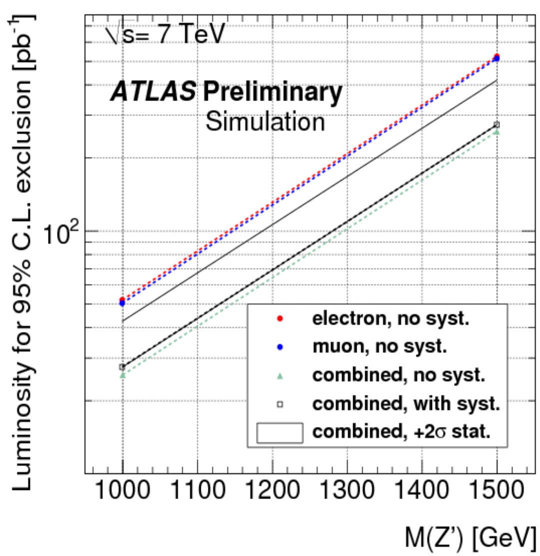
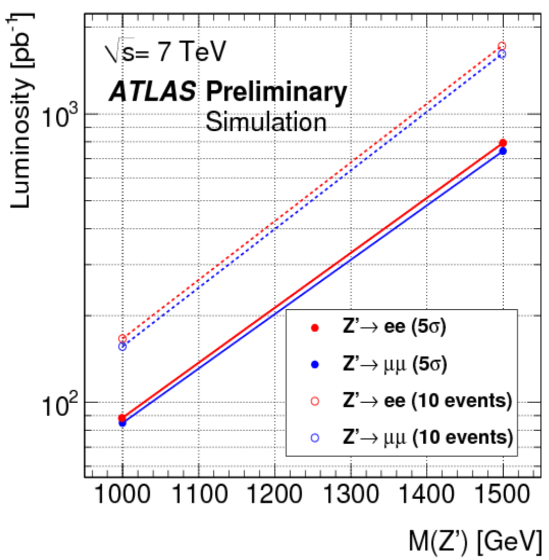
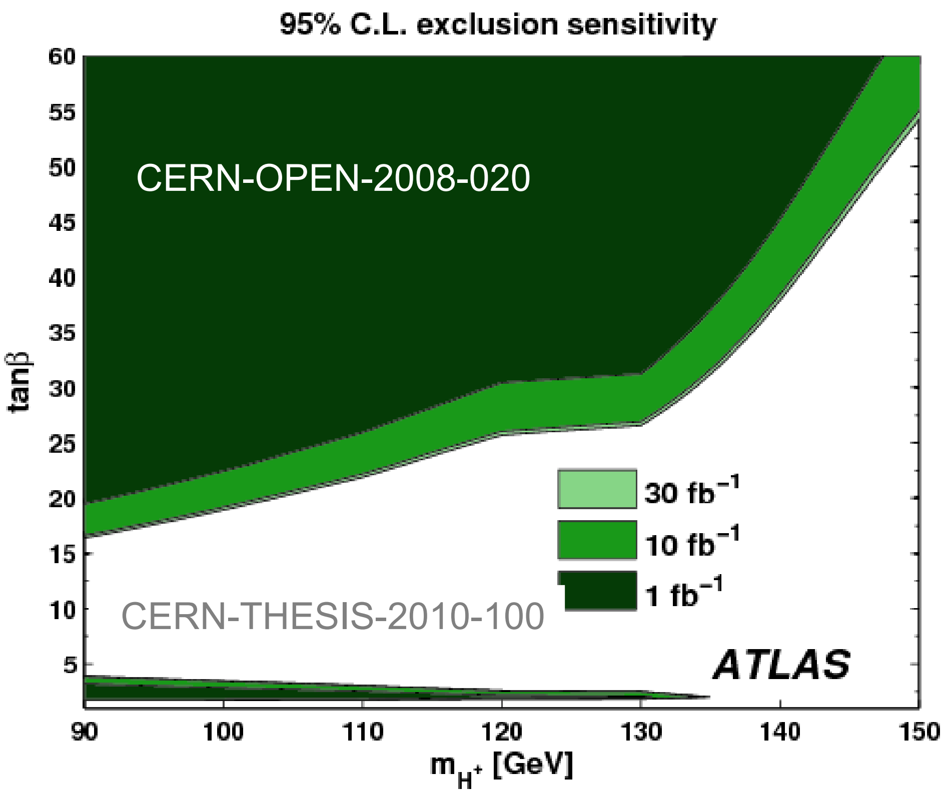




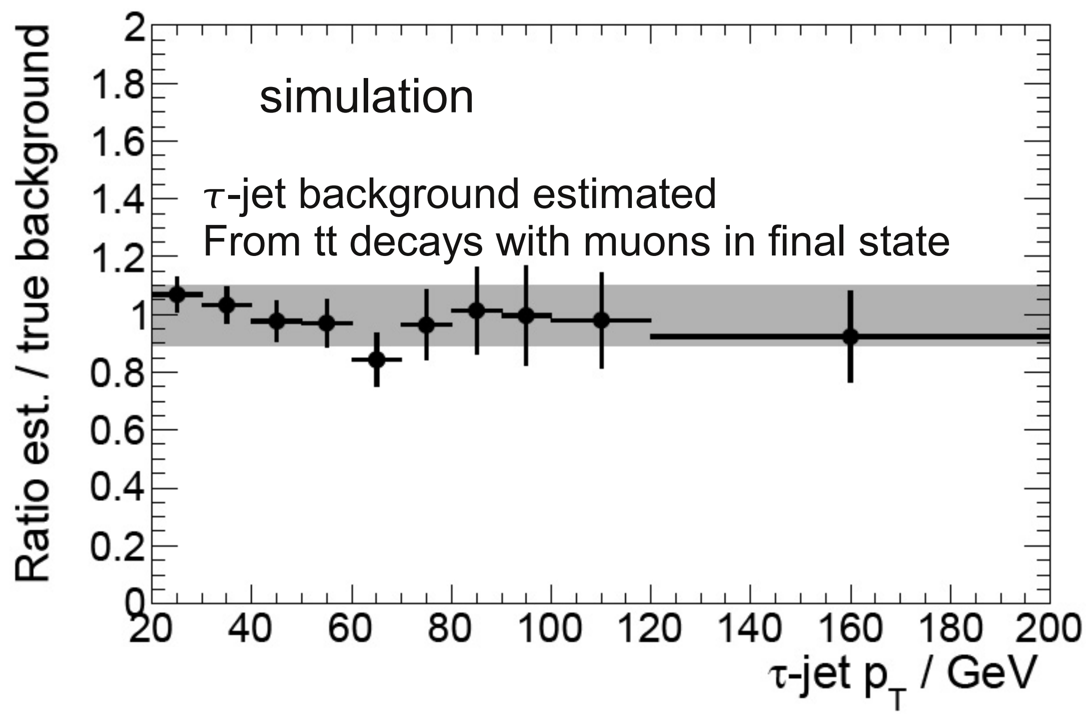
Charged MSSM Higgs Search: $H^{\pm}\to\tau^{\pm}\nu$

MPP has been a main developer for the charged MSSM Higgs Search
In the channel $tt\to(Wb)(H^{+}b)\to(l\nu b)(\tau_{jet}\nu b)$

PhD thesis: Thies Ehrich.



Data-driven background estimation
Now being applied on the current data
(also for MSSM $H\to\tau\tau$ search)

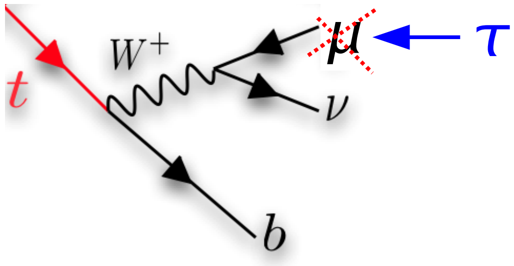


tT background to SUSY

- SM processes with similar to SUSY signatures
  - W and Z, tT production (due to large missing E_T energy originated by ν)
  - QCD multi-jet production
- Estimation of SM background from data control samples is essential

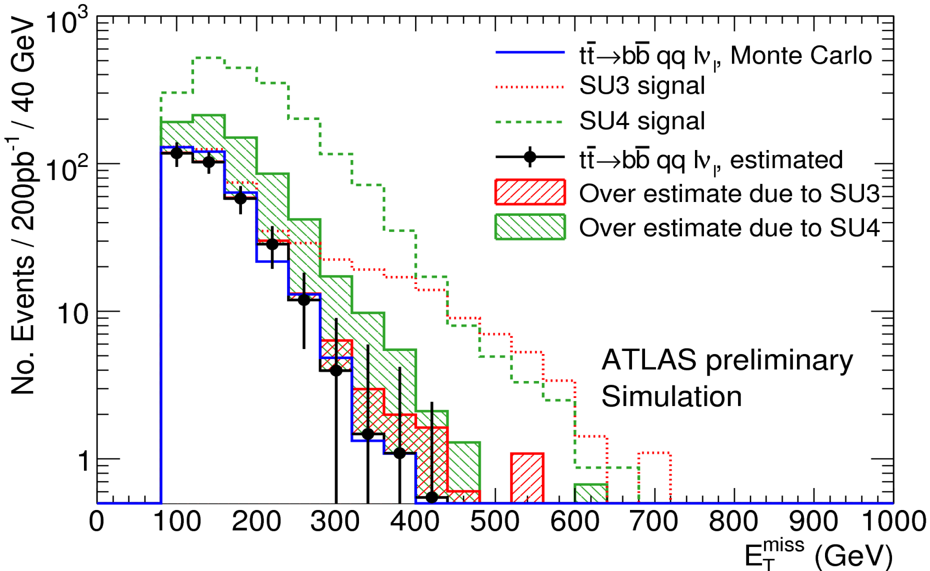
Example: tT background to 0-lepton SUSY search

- Dominant contribution from events $t \to b\tau\nu$ with later hadronic τ decay
- Estimation of this background from data is complicated (τ jets are hard to recognize)



The solution: select from data $t \to b\mu\nu$, replace muon "manually" by tau

0 lepton, 10 TeV, 200 nb^{-1}



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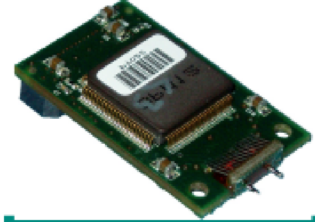
- And simulate decays of hand-made tau again:
  - Truth replacement: form a jet from true tau decay hadrons and apply jet response function
  - Embedding: passing tau decay through detector simulation

Missing E_T in the 0-lepton final state:

- real (–) and estimated (-●-) tT content are in good agreement.



The TX Failures

- TXs send clock & command signals to modules
- All replaced in July '09 after failures (ESD)
- March 2010: started to fail again
- 632 TXs in ID (360 SCT, 272 Pixel)
- 487 failures (282 SCT, 205 Pixel) (as of Nov. 14th)
- current SCT failure rate: ~2-3 per day
- SCT can use redundancy from neighbouring module
  - Inefficiency from death to end of run
  - Inefficiency from death to end of fill if no redundancy available
- Pixel does not have redundancy scheme
- SCT only replaces TXs that cannot use redundancy
  → save spares
- Priorities
  - Produce more spares to bring us to 2012 shutdown
  - Understand and solve problem and produce new TXs
  - Understand if on-detector RXs have same issue